







*de. Roach*

# XVII INTERNATIONAL CONGRESS OF ENTOMOLOGY

Hamburg  
Federal Republic of Germany  
August 20—26, 1984



*Gilbert*

## Abstract Volume







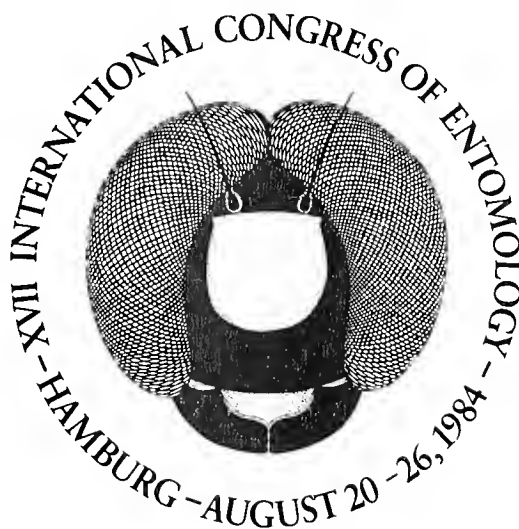
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**XVII  
INTERNATIONAL CONGRESS  
OF ENTOMOLOGY**

(17<sup>th</sup> : 1984 : Hamburg, Germany)

Abstracts,

**Hamburg  
Federal Republic of Germany  
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**Abstract Volume**





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P 1. ....



R 1.1.  
1

## NEW HIERARCHICAL SYSTEM OF ARTHROPODS, MAINLY REFERRING TO INSECTS

MIRCEA ALEXANDRU IENISTEA

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Modern researches demonstrate: I. Present phylum ARTHROPODA is heterogeneous and polyphyletic. Author considers as proved enough to recognize its main divisions as phyla: TRILOBITOMORPHA, CHELICERATA, PANTOPODA, CRUSTACEA, CHILOPODA, PAUROPODA, DIPLOPODA, SYMPHYLA, PROTURA, COLLEMBOLA, DIPLURA, INSECTA. Consequently, most of their orders automatically become classes, their subdivisions being analogically promoted as well. II. Total different measure used to classify ARTHROPODA and VERTEBRATA created large contend-discrepancies, far more diverse in present families of the former, than in orders of the latter. NATURE itself claims for radical general revision, in eliminate such discrepancies, in order to reach an equilibrated system. In INSECTS mainly, promotion of most subdivisions will result.

R 1.1.  
2

## SOME NUMERICAL METHODS OF PHYLOGENETIC TREE CONSTRUCTION

R.G. DAVIES

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The most popular techniques for numerical phyletic analysis are based on so-called Wagner trees (e.g., Farris (1970) Syst. Zool., 19: 83). A new group of procedures is proposed, based on a more direct application of Hennig's methods and intended to be used with binary or multistate data. The new techniques have been implemented by Fortran computer programs. The methods and some of the properties of the resulting trees are discussed in relation both to artificial data sets and to a number of entomological examples which have already been considered on more traditional, non-numerical cladistic lines. Emphasis will be laid on some of the criteria available for evaluating and comparing phylogenetic trees and on the relationships between the new methods and those used to yield phenetic classifications.

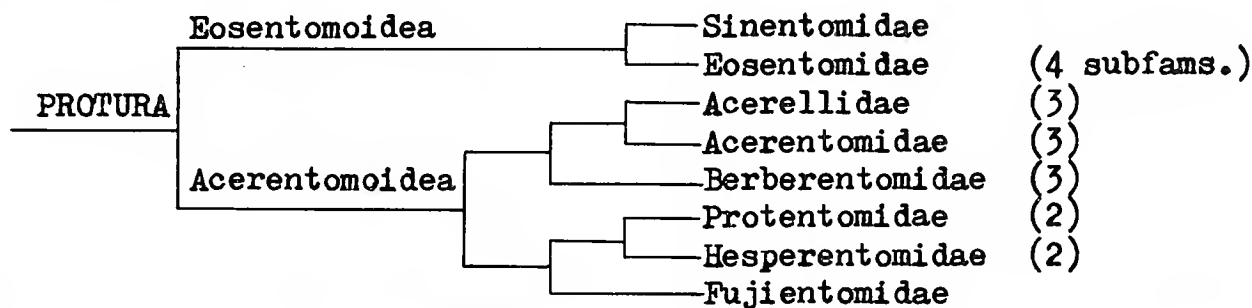
R1.1.  
3

# NEW IDEA ON PHYLOGENY OF PROTURA

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Based on the faunal investigation of Chinese Protura, the studies on the postembryonic development of Sinentomon and Eosentomon, and the ultrastructure of spermatozoa of different genera, the author puts forward a new idea on phylogeny of Protura: the Acerentomoidian is comparatively the primitive group, whereas the Eosentomoidian, which possess tracheal system, is the specialized group. And according to this new conception, a tentative phylogenetic arrangement of the known genera of Protura, including 8 families and 17 subfamilies, was proposed:



R1.1.  
4

## THE IDIOCERIDE LEAFHOPPERS IN CHINA (HOMOPTERA: CICADELLOIDEA: IDIOCERIDAE)

KUOH CHUNG-LIN FANG QING-QUAN

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This paper is the first report on studies of Idioceridae on the vast areas in China.

As the results of past 25 years, the authors et al. have made a large collections on Chinese Idioceridae. Among them we found a new genus and 44 new species. In this paper, the list of species with distribution and hostplant, the key to genera and key to species of each genus, and the characteristics of Chinese Idioceridae on geographical distribution, host and appearance are reported.

R 1.1.  
5

REGULARITIES OF THE GENESIS OF ORTHOPTERA FAUNA  
IN TRANSCAUCASIA

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Recently about 250 species of Orthoptera in Transcaucasia are known, 20% of which prove endemic and subendemic. They have different origin but the ancient Mediterranean had the most significant influence on the formation of fauna. There are a number of proofs of the penetration of Mediterranean Orthoptera and species from the Near East and Asia Minor and Iran here in the period of the Miocene and Pliocene.

European-Siberian species penetrated both through the Balkans and Asia Minor in the Miocene-Pliocene and the glacial period of the Pleistocene through the Russian Plain.

At present the process of species formation occurs more intensively in the mountainous regions of Transcaucasia.

R 1.2.  
1 Mesozoic Lepidoptera with emphasis to early evolution  
of the order

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The oldest evidence of true Lepidoptera is from Upper Jurassic. Triassic <sup>+</sup>Eocoronidae assigned to this order are rather comparable with Mecoptera and Trichoptera. Upper Jurassic and Lower Cretaceous stem-group <sup>+</sup>Eolepidopterigidae / <sup>+</sup>Eolepidopterix and <sup>+</sup>Undopterix from tuffites/ occupy intermediate position between contemporary Zeugloptera and Glossata /Dachnonypha+Monotrysia+Ditrysia/. In Cretaceous ambers Lepidoptera are represented by Zeugloptera, Dachnonypha, Incurvariidae and ?Tineoidaea of the modern type. Nepticulid leaf-mines were found in Upper Cretaceous. Reconstruction of archetype for Eolepidopterigid is given. New discoveries of Jurassic and Cretaceous lepidopterous insects and relationships of fossil and recent taxa are discussed.



**R1.2.** HEPIALOID MOTHS: A REVIEW OF THEIR DIVERSITY,  
**2** PHYLOGENY AND CLASSIFICATION.

EBBE S. NIELSEN

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The Hepialoidea and Mnesarchaeoidea constitute the lepidopteran infraorder Exoporia. Five families have been recognized in the Hepialoidea: Neotheoridae, Anomosetidae, Prototheoridae, Palaeosetidae and Hepialidae. The first three of these families are all monobasic and their distribution is limited; the small family Palaeosetidae, as traditionally understood, occurs in Australia, Asia and South America; the Hepialidae, the 'ghost moths' or 'swifts', are by far the most successful non-heteroneuran family being world-wide in distribution and comprising approximately 80 genera and more than 500 species. Recent taxonomic and morphological studies by several workers indicate that the Palaeosetidae are not monophyletic and that no autapomorphies exist for the Hepialidae. However, several new characters with bearing on the phylogeny of the Hepialoidea have also been discovered. These characters and their impact on the phylogeny and classification of the Hepialoidea are discussed.

**R1.2.** PHYLOGENETIC RECONSTRUCTION IN Zygaena F. (Lepidoptera):  
**3** ENZYME-ELECTROPHORETICAL AND MORPHOLOGICAL STUDIES

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W. HENNIG's method of phylogenetic systematics involves problems, particularly at the species level. With regard to the 'Grundplan' (following HENNIG) of Zygaena, it is difficult to decide whether specific characters are plesiomorphic or apomorphic. Therefore, results from enzyme-electrophoretic analysis as well as comparative morphological and biogeographical data are used in order to reconstruct the phylogeny of Zygaena. In particular, biochemical data provide hints for interpreting the evolutionary sequence of characters ('Lesrichtung'). In this way, sister group relationships (HENNIG) of subgenera and interspecific relationships are identified. Both morphological/biogeographical and biochemical results suggest a division of Zygaena into two sister groups, according to whether the larval food plant belongs to Apiaceae or to Fabaceae.

R 1.2.  
4

S.C. GOEL

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The consumption of the food during the larval stages influenced the average pupal weight. This shows high coefficients of correlation between the two at different sexes. The regression equation so evolved resulted into an enhanced live pupal weight by 36.13 mg on an average consumption of 1 g of live food during its larval stages. The weight loss is higher in females than the males whereas average loss is highest on the day preceding the adult emergence.

Morphological interpretations of labial palpa, maxillae, tibia, internal structure of tibial sclerite, serrated margin of abdominal spiracles and cremaster are important taxonomically for a pupa of Spodoptera litura (Fabr.). Colour, size, antennal elevations, genital openings and intersegmental lines are the features of sex differentiation. The caterpillar chaetotaxy maintained over the pupal body is also partially defined under the pupal chaetotaxy.

R 1.2. BIOCHEMICAL SYSTEMATICS AND SPECIATION IN THE LEAF-MINING GENUS  
5 *ECTOEDEMA* BUSCK (NEPTICULIDAE, LEPIDOPTERA)

STEPH B.J. MENKEN and JAN BROUWER

Department of Animal Systematics, Vrije Universiteit, Amsterdam

Genetic variation at 12-18 loci coding for enzymes and general proteins in natural populations of some 25 western european species in the genus *Ectoedemia* was investigated. The following generalizations are advanced:

- (1) Differentiation among populations within the same species is very low.
- (2) Differentiation among different species is high. Genetic identities are at most 85% and in general lower than 60%. Consequently allozyme variation analysis is very useful in (sibling) species discrimination and one single population can characterise the whole species.
- (3) Total heterozygosity differs much interspecifically but not intraspecifically.

A phylogenetic analysis will be presented and (dis)agreements with a morphological analysis will be discussed.

From the generally low genetic identities among species and the absence of small endemics it can be concluded that no recent (sympatric) speciation has occurred and further that allopatric speciation is the mode in this group.

**R1.2.**  
**6** ANTENNAL SENSILLA OF NEPTICULIDAE (LEPIDOPTERA: NEPTICULOIDEA),  
MORPHOLOGY AND PHYLOGENETIC IMPLICATIONS.

ERIK J. VAN NIEUKERKEN and HENK DOP

Department of Animal Systematics, Vrije Universiteit, Amsterdam

The antennal morphology of about 40 species of Nepticulidae, representing most genera, has been studied with a SEM. The morphology of the flagellar segments shows a high degree of consistency throughout the family. Sensillar types comprise 1-3 sensilla trichodea, 1-3 s. chaetica (type I), 12 s. chaetica (type II) and 0-2 s. coeloconica per flagellar segment. In addition two large, previously unknown structures are present. They are blister-like evaginations of the flagellar cuticle and are named as sensilla vesiculocladum and to be classified as multiporous thin-walled chemoreceptors. They show various forms, of which the five-branched type is thought to be the ancestral form. The s. vesiculocladum is an autapomorphy for Nepticulidae and homologous with the ascoid sensilla of *Opostega*, thus supporting a sister-group relationship with the Opostegidae. It is supposed that the s. vesiculocladum, as the most important chemoreceptor, replaces the s. trichodea of other Lepidoptera.

**R1.2.**  
**7** SCENT APPARATUS-TYPES AMONG SOME PENTATOMOMORPHA  
(INSECTA:HEMIPTERA) AND THEIR BEARING ON CLASSIFICATION<sup>1</sup>

IMTIAZ AHMAD  
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Metathoracic scent apparatus in Heteroptera has long been considered useful in ascertaining phylogenetic status (Poisson, 1924; Brindley, 1930; Caryon, 1950, 1962 and 1971; China, 1955; Drake and Davis, 1960; Waterhouse and Gilby, 1964; Cobben 1968; Hepburn and Yonke, 1971 and Ahmad and Khan 1973) but recently Cobben (1978) expressed strong discontentment on the occurrence of parallelism in these structures which according to him made it unuseful for systematic or phylogenetic treatment. There not only exist disputes in the nomenclatorial and phylogenetic status of infra groups of higher ranks within Heteroptera such as Cobben (1978) proposed to abandon "Geocorisae" for it is polyphyletic, there also exist a series of disputes both in the ranks and in the phylogenetic positions of the infra groups under this division (Stys, 1975; Stys and Kerzhner, 1975; Cobben 1978; Ahmad, 1979 and 1980 and a series of papers by leading heteropterists in the Rostria Suppl. 33, 1981). During the present studies a definite course of evolution of scent apparatus and its several types within Pentatomomorpha have been recognized and in this light the phylogenetic status of several infra groups within this division are also briefly discussed.



**R1.2.** ANAGENETIC TRENDS IN THE ARRANGEMENT OF INTERNAL ORGANS  
8 IN MAYFLY LARVAE (EPHEMEROPTERA)

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Larvae of more than 100 mayfly genera were investigated. Abdominal ganglia 2-7 (ganglion 1 usually absent) tend to form a shallow band with fused connectives or ganglionic mass with thoracic ganglia. Within the tracheal system, there is a tendency to increase the number of anastomoses and to reduce visceral tracheae. The alimentary canal is more uniform, with a specialized crop in carnivores. The malpighian tubules, originally entering the gut individually form lower buds or four pairs of common trunks. Gradual association of trunks leads to only a single pair, sometimes resembling "ureter". There are apparent tendencies to produce gonads to prothorax, to multiply the number of follicles, to reduce their size, and to move originally dorsal gonads to the ventrolateral position. These data are very valuable for study of the phylogeny and hinger systematics of the order: primitive arrangement of internal organs is conserved in some morphologically derived genera and vice versa.

**R1.3.** Phylogeny and classification of lower Heteroptera  
1

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Viničná 7, 128 44 Praha 2, Czechoslovakia

The infraorders Enicocephalomorpha and Dipsocoromorpha are the earliest surviving stocks of Heteroptera. Our conception of their structural diversity has been considerably amplified by recent discoveries of several new, strikingly plesiomorphic, taxa for which new higher groups had to be erected (Enicocephalidae: Monteithostolinae, Phallopiratinae; Stemmocryptidae). The phylogeny and classification of both infraorders are reviewed with particular attention to the above groups, and the relationships of Enicocephalomorpha and Dipsocoromorpha to the other major heteropteran taxa are considered. The role of parallel evolution in the phylogeny of both infraorders is emphasized.

R1.3.  
2

EVOLUTION OF FEEDING HABITS AND ASSOCIATED STRUCTURES  
IN LAND BUGS (HEMIPTERA: GEOCORISAE) AND THEIR PHYLOGENY

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AND INSECT NATIONAL MUSEUM, N.S.F., ISLAMABAD.

Change in feeding habits has resulted in structural changes in pre-existing organs or in the origin of new organs associated with feeding. This has also probably influenced other internal structures particularly those associated with defense resulting into a modification in the position of the metafurca and degree of development of the posterior process of mesofurca. The occurrence of simple vesicular salivary glands, a simple pylorus and ileum, absence of gastric caeca associated with location of metafurca at anterolaterally produced angles of furca sternum at inner anterolateral angles of meta coxal cavity are most probably plesiomorphic conditions. The latter situation of meta-furca is the one predominant in auchenorrhynchous Homoptera (Kramer, 1950; Afzal and Ahmad 1978 and Ahmad and Afzal, in press). On the other hand absence of posterior process of mesofurca is also plesiomorphic. All examples of "Omphalium type" of scent apparatus illustrated by Cobben (1978) appear to be strongly associated with posterolateral displacement of metafurcal bases. On the other hand in all known primitive landbugs showing polliniphagy, predation or occasional polyphagy but no secondary sap-sucking habits, "Diastomium type" of scent apparatus associated with anterolaterally placed metafurca is encountered. This appears to reverse the scheme of Caryon (1971) and Cobben (1978). These conditions are presently discussed in 96 species representing 25 families of Geocorisae.

R1.3.  
3 A REVIEW OF TAXONOMIC CHARACTERS AND THE HIGHER CLASSIFICATION OF THE ISOMETOPINAE (HEMIPTERA: MIRIDAE).

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The Isometopinae are predaceous bugs characterized by the possession of ocelli, two-segmented tarsi, a usually strongly vertical head with very large compound eyes occupying most of it, and a distinctly cryptic habitus. Some earlier authors classified them as a distinct family but they are now generally regarded as a sister group of other Miridae.

The subfamily has hitherto been subdivided into two tribes VIZ: Isometopini and Diphlebini. The characters used for this and other taxonomic ranking in the subfamily are reviewed, and their shortcomings highlighted. Information is also provided on such previously little studied characters as membrane pubescence, femoral trichobothria, pretarsus, male and female genitalia. The Myommara are excluded from the Isometopini and accorded full tribal status. The zoogeography of the subfamily is discussed.

R1.3.  
4

MORPHOLOGY OF HEAD OF SOME MEMBRACOIDS (INSECTA: HOMOPTERA)  
AND THEIR BEARING ON CLASSIFICATION.

HAFIZUR RAHMAN AND IMTIAZ AHMAD - Professor of Zoology, Federal Government Urdu Science College, Karachi (Pakistan).  
Professor of Zoology-Entomology, University of Karachi, Karachi-32, (Pakistan).

After the classical work on the head of general insects earlier by Spooner (1936) and more recently by Matsuda (1960) and on a membracid by Kramer (1950) it is obvious that these structures could be effectively used in the classification of Membracoidea. Presently representatives of the ten genera and 44 species of the family Membracidae from Pakistan, Azad Kashmir and Bangladesh have been studied with reference to their head and associated structures and their bearing on the phylogeny of the group is briefly discussed.

R1.3.  
5 EVOLUTION OF THE LETHAEINI, WITH EMPHASIS ON THE WESTERN HEMISPHERE  
FAUNA (HETEROPTERA: LYGAEIDAE)

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A cladistic analysis of the Lethaeini clearly shows that the New World fauna does not constitute a monophyletic assemblage. Characters including dorsal cephalic iridescence; metathoracic scent gland auricle, and male and female genitalia indicate that two distinct clades are present in the Western Hemisphere. Wing polymorphism, expressed as brachyptery and coleopteroidy, has evolved several times, once possibly in connection with myrmecophily. Sexual dimorphism involving changes in several complex structures has also arisen independently more than once. Autapomorphic specializations characterize many genera in both the new and old worlds, and as a result the tribe is morphologically diverse. Zoogeographic analysis based on the cladogram shows trans-oceanic sister groups at the generic and generic-group levels. The distribution of related taxa among continents of the Southern Hemisphere suggests an early diversification on Gondwana.

**R1.3.** A INTERESTING COLOPHA SP ON SCIRPUS HOLOSCHOENUS IN SPAIN.  
**6** (HOM. APHIDOIDEA PEMPHIGIDAE ERIOSOMATINAE)

NIETO NAFRIA, J. M. and MIER DURANTE, M.P. .

Departamento de Zoología, Facultad de Biología. Universidad de León. LEON (E)

Colopha (Aphidoidea, Pemphigidae, Eriosomatinae) is a genus with seven species of aphids. Five of which, some of them little know, live in the oriental part of the Palearctic Region. Three species are found in North America; and only one is known in Europa: Colopha compressa.

We describe a new species of Colopha, collected at several localities in Spain.

We list the peculiar characteristics of the apterous partenogenetic females, the single morph yet know; and we also describe its interesting habits on Scirpus holoschoenus.

Host-plant and habits are a sufficient basis for separating this species from others Colopha spp and Kaltenbachiella spp, which are very close to them.

**R1.3.** CHECK-LIST OF APHIDS (HOM. APHIDOIDEA) OF SPAIN AND A LIST OF  
**7** FOOD-PLANTS OF APHIDS OF SPAIN.

MIER DURANTE, M.P. (1), DIAZ GONZALEZ, T.E. (2), AND NIETO NAFRIA, J.M. (1)  
(1) Dpto. Zoología, (2) Dpto. Botánica. Fac. Biología. Univ. León. LEON (SPAIN)

We give an up-dated check-list of the aphids (HOMOPTERA APHIDOIDEA) of Spain, with a list of relevant Spanish bibliography.

We give for the first time a list of host-plants of aphids found in Spain. It is a critical list of all references to food-plans of aphids in Spain



R1.3.

8

### A KEY FOR IDENTIFYING APHID SUBFAMILIES IN IRAN

No 12, Shahid Omrani St., S.H. HODJAT  
Zafar Ave., TEHRAN-IRAN.

Middle Eastern aphids are divided into 7 families and 15 sub-families by Bodenheimer and Swirski(1957) using Borner's(1952) system of classification- A list of 8 families and 17 sub-families of aphids from Turkey is presented by Canackcioglu(1975). In our preliminary studies of aphids from Iran we published keys to two sub-families, six tribes and 55 genus (Eastop and Hodjat, 1979). In this study morphological characters to six families and 17 sub-families of aphids recorded from Iran is described and a key is written for their identification.

R1.3.

9

### SCALE INSECTS OF CENTRAL EUROPE (HOMOPTERA: COCCOIDEA)

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The area studied, central Europe, includes most of the European land mass with temperate climate, excluding the Mediterranean, Atlantic and Baltic sea coast areas, Scandinavia and Finland. There are 231 known species of scale insects in Central Europe belonging to 93 genera and 12 families, not including the 75 introduced greenhouse and house plant infesting species. Pseudococcidae, the mealybugs, comprise the largest family, with 32 genera and 85 species. Unfortunately, this group along with the Eriococcidae are poorly known in this area. Poaceae or the grass family serves as host for the largest number of scale insects, followed by Rosaceae. The greatest number of Central European species are mesophilous, only 2 can be considered truly montane and about 12 are of boreo-montane distribution. There are 3 hygrophilous and 6 xerophilous or thermophilous species found in the steppe habitats. The species can be further classified by zoogeographical distribution as follows: Cosmopolitan 8 (2 or 3 of these introduced), Holarctic 8, Trans-Palearctic 26, Black-Sea-Caucasus elements 4, Southwest-Siberian elements 4, Mediterranean elements 14 species, and the remainder appear to be endemic to Central Europe. At least 7 species of Coccoidea are common pests on shade and ornamental trees in artificial habitats.

**R1.3.** DESCRIPTION OF THE MALE STAGES OF LEUCASPI  
**10** RICCAE (HOMOPTERA: COCCOIDEA: DIASPIDIDAE)

SAMIA M.A. NADA and ZENAT K. MOHAMMAD

Plant Protection Institute, Ministry of Agriculture, Egypt.

The adult male of this scale insect passes through four immature forms: two nymphs, prepupa, and pupa.

For lack of space, all forms are here presented in detailed illustrations without much verbal descriptions except for the adult male which is fully described because of its significance in the taxonomy of this group.

Meanwhile, certain differences are pointed out as indicators for the developmental pattern of this species.

**R1.3.** DEVELOPMENTAL PATTERN OF CERTAIN PLANOCOCCUS MEALYBUGS (HOMOPTERA:  
**11** COCCOIDEA: PSEUDOCOCCIDAE)

YAHIA M. EZZAT<sup>1</sup> and AHMAD I. EZZ<sup>2</sup>

<sup>1</sup>Faculty of Science, Al Azhar University and <sup>2</sup>Ministry of Agriculture, Egypt

The sequence of change in certain characters after moulting revealed the similarity in developmental pattern among the female nymphs of Planococcus citri (Risso) and its closely allied species, P. ficus and P. vitis. All in the first instar appear with their relatively few setae and trilocular disc pores obviously arranged in longitudinal rows.

After the first moult, these structures become more in number, hence appear on abdominal segments, in simple transverse rows rather than in few longitudinal rows.

In the third instar nymphs, setae and trilocular disc pores become numerous enough to appear in wide rows. Moreover, tubular ducts and multilocular disc pores start to show up; and antennae become seven instead of six jointed.

**R1.4.**  
**1** FOSSIL INSECTS FROM A LATE GLACIAL (LATE WEICHSELIAN) SEQUENCE AT  
LIETH, NEAR HAMBURG, GERMANY.

ANNE MORGAN<sup>1</sup>, ALAN MORGAN<sup>2</sup> & MATTHIAS HUFNAGEL<sup>3</sup>.

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Assemblages of fossil Coleoptera have been examined from a 1.6 m sequence of peats and sands at Lieth in Schleswig-Holstein. Dates of  $11,788 \pm 190$  and  $11,060 \pm 250$  yrs B.P. have been obtained at two levels in the organic sequence. Analyses of insects at ten horizons through the section have provided over 7,000 individual fragments. At the base there are several species with northern affinities indicating cool conditions in this area around 12,000 years ago. By about 11,000 yrs. B.P. there is a much richer assemblage, particularly abundant in Staphylinidae and Curculionidae. The fauna is consistent with a rich sedge-fen environment and is believed to be approximately contemporaneous with a worked flint fragment which was found in the sample. The paleoecology of the Lieth area in Late Glacial time is discussed, together with the zoogeographical implications of the Coleoptera. Many faunas of this age have been described from Britain, but there are only a few such studies in Europe.

**R1.4.**  
**2** EVOLUTION OF MUSHROOM FEEDING IN GYROPHAENINE STAPHYLINID BEETLES  
(COLEOPTERA: STAPHYLINIDAE: ALEOCHARINAE)

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Members of the aleocharine subtribe Gyrophaenina are obligate inhabitants of fresh mushrooms as both larvae and adults. In this habitat they feed by grazing maturing spores, basidia and hyphae from the hymenium layer. Gyrophaenines probably arose from bolitocharine-like ancestors which fed facultatively on fungal hyphae and spores. Increasing reliance on hymenium scraping as a feeding mode is reflected primarily in modification of the maxillae as spore scraping structures. In addition, life cycle adaptations to the ephemeral nature of gilled mushrooms was required for use of this portion of the mushroom habitat.

**R1.4.** THE SYNONYMS OF NORTH AMERICAN ALEOCHARINAE, DESCRIBED BY EUROPEAN  
**3** AUTHORS BETWEEN 1800 AND 1853

LOHSE, GUSTAV ADOLF

Schleusentwiete 5 D - 2000 Hamburg 65 G.F.R.

The types of species of Staphylinidae subfamily Aleocharinae, described by GRAVENHORST, ERICHSON, SACHSE, MANNERHEIM and MAEKLIN were studied and compared with the Aleocharinae-types of the CASEY-collection in Washington. 15 of these species were found as redescribed by CASEY as new species, the name of them must be regarded as invalid junior synonyms.

Original names	Synonyms	Valid names
Aleochara dichroa Gravenhorst	Stethusa soroella Casey	Stethusa dichroa Grav.
Homalota trimaculata Erichson	Pleurotibia suturalis Cas.	Bolitochara trimaculata Er.
Homalota festinans Erichson	Synaptina consonens Casey	Microdota festinans Er.
Homalota vestigialis Erichson	Micrearota fecunda Casey	Microdota vestigialis Er.
Homalota luteola Erichson	Pancota panda Casey	Pancota luteola Er.
Homalota recondita Erichson	Arisota tetricula Casey	Arisota recondita Er.
Homalota ambigua Erichson	Strigota oppidana Casey	Colpodota ambigua Er.
Oxypoda sagulata Erichson	Oxypoda latebricola Casey	Oxypoda sagulata Er.
Falagria longicornis Sachse	?	Apocellus sp.
Falagria amabilis Sachse	?	Apocellus sp.
Silusa gracilis Sachse	Silusa rutilans Casey + Leptusa tricolor Casey	Leptusa gracilis Sachse
Homalota maritima Mannerheim	Adota massetensis Casey	Adota maritima Mannh.
Homalota picipennis Mannerheim	Dimetrota carlottae Casey	Dimetrota picipennis Mannh.
Homalota geniculata Mäklin	Tarphiota insolita Casey	Tarphiota geniculata Mäklin
Homalota breviscula Mäklin	Acrotona prudens Casey	Atheta breviscula Mäklin
Homalota litoralis Mäklin	Emplenota longiceps Casey	Emplenota litoralis Mäklin

**R1.4.** UPDATING OF BATHYSCIINAE (COL.CATOPIDAE) OF THE IBERIAN  
**4** PENINSULA

O.ESCOLA B.

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After the magistral "Monographie des Bathysciinae" (JEANNEL,1924) the latest writing up on the Spanish group was carried away in 1953 by ESPAÑOL.

The aim of this paper is to gather all records,published or new of Bathysciinae in the Iberian Peninsula.No cave records are known for Bathysciinae neither in the Balearic and Canary Islands nor in Portugal.

The bringing up to date of the whole of the subfamily shows the continuous enlargement suffered since 1953.It also means a more accurate definition of species of a great variability or of supraspecific taxa better fixed.

Between 1924 and 1953 26 species or subspecies have been described whereas since 1953 the total number has increased in at least 60 taxa.

R1.4.  
5

A NEW WEST INDIAN GENUS OF MONOMMIDAE (COLEOPTERA) WITH COMMENTS  
ON THE PHYLOGENY OF THE MONOMMIDAE-ZOPHERIDAE LINEAGE.

MICHAEL A. IVIE

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A new species and genus of the family Monommidae has been discovered on St. John, U. S. Virgin Islands in the West Indies. The very large number of plesiomorphic character states present in this new taxon is remarkable, and it appears to represent the most basal clade known on the monommid lineage. This genus has allowed polarization of several characters of the Zopheridae-Monommidae line, and indicates an origin of the Monommidae from within the present Zopheridae. The evolutionary, zoogeographic, biological, and nomenclatorial implications of this find are discussed.

R1.4.  
6

TRANSLOCATION OF FAUNAL ELEMENTS BY SHIFTING SUBSTRATE

S. ENDRÖDY-YOUNGA

Transvaal Museum, Pretoria

The origin of dune specialist tenebrionid beetles was hitherto a disputed and unsolved problem. The discovery of northward shifting sand masses in the southern Namib provided the solution. Isolated barchan dunes carry populations of southern species at present at an average speed of 40 m per annum. Two main evolutionary centres could be distinguished: southern Namib for the genus *Lepidochora* and central Namib for *Vernayella* and for the subgenus *Cardiosis* of *Zophosis*. The evolutionary centres are marked by the plesiomorph species of the genera. All of them dispersed northward only, apomorphic species reaching the Cunene River.

R1.4.  
7

ANALYSES OF PHYLOGENY AND BIOGEOGRAPHY OF THE PENICHROLUCANINAE  
(COLEOPTERA: LUCANIDAE)

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The Penichrolucaninae is a small subfamily of rare Lucanidae consisting of two species from northern South America (one of which is described as new) and five species from the Indomalayan region. A monophyletic origin for the subfamily is indicated because all included taxa share certain character states not possessed by other Lucanidae. A relationship hypothesis for the species is presented. Two alternate biogeographical hypotheses to explain the current distribution of these beetles are proposed. The first postulates a Holarctic radiation in the Paleogene with subsequent retreat to tropical refuges in Malaya (post-Miocene) and South America (post-Pliocene). The second postulates a Gondwanan origin/radiation with subsequent vicariance to South America due to continental drift (Upper Cretaceous), dispersal from Africa to Asia (Miocene), and probable extinction in Africa (Miocene onward). The conclusions of the biogeographical analysis (either scenario) support, by congruence, the hypothesis of relationships proposed for the subfamily.

R1.5.  
1

CARABID SYSTEMATICS AND CHROMOSOME NUMBERS

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Own data and a literature review give the chromosome number for more than 300 carabid species, this is less than 1% of the known species of the group. The diploid numbers are between 8 and 69. Some tribes and genera with several karyotyped species are uniform in chromosome number while others have a large variation in this character. Such differences may reflect an artificial group size or alternatively a different rate or mode of karyotyp evolution in the different branches of the phylogenetic tree.

Some current hypotheses about basic and ancestral karyotypes and about "trends" in chromosome evolution of carabids are discussed.



## R1.5. Microevolution in Chrysocarabus

2

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The Carabus subgenus Chrysocarabus is characterised by a number of pairs of species which are more or less closely related. With the exception of one wide spread species (*C. auronitens*) their distribution is restricted to SW-Europe, where in several regions two or more species occur together within the same place and the same habitat. Two closely related species (*C. lineatus* and *C. splendens*) show character displacements in some morphological and a chromosomal character and they produce hybrids which can be partly distinguished by morphological characters. Affinity chromatography and isoelectric focusing of proteases gives band patterns which allow to discriminate between the species and hybrid individuals. Field studies and lab experiment prove that the main ecological differences between *C. lineatus*, *C. splendens*, and their hybrid exist in the diurnal activity distribution.

## R1.5. THE LARVA OF ANTILLISCARIS MUTCHLERI (BÄNNINGER) (COLEOPTERA: CARABIDAE: SCARITINI) WITH A DISCUSSION OF GONDWANIAN RELICTS IN THE WEST INDIES

3

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Antilliscaris are a small group of flightless, montane carabid beetles endemic to Puerto Rico and Hispaniola of the West Indies. The first known larva of this group, Antilliscaris mutchleri (Bänninger), is briefly described. A cladistic analysis of both adult and larval characters aligns Antilliscaris with genera of the Afrotropical Region, not with the mainland fauna of the Western Hemisphere. Similar trans-Atlantic distribution patterns are summarized and the significance of these findings are discussed.

# R1.5. THE DEVELOPMENT TYPE OF CARABIDAE IN THE TEMPERATE ZONE

## 4 AS A TAXONOMIC CHARACTER

KAREL HURKA, Faculty of Sciences, Charles University  
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The life cycle of carabids in the temperate zone is governed by the annual rhythm of climatic conditions; all species are apparently univoltine. The specific developmental type ensures, in the absolute majority of species, synchronization of reproduction. There are two basic developmental (breeding) types, namely with and without larval dormancy in the developmental cycle. The author's field and laboratory findings combined with literary data demonstrate that, from the taxonomic point of view, the related species are of the same basic developmental type, although they live in different habitats. The statement is demonstrated on the example of species-groups, subgenera and genera of the subfamily Pterostichinae, but it concerns all Carabidae.

# R1.5.

## 5 The Cochise Filter Barrier: The major speciation mechanism in the Agonum extensicolle group (Coleoptera: Carabidae)

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The Agonum extensicolle species group comprises 7 species. The phylogeny of the group is estimated using genetic distance data obtained by horizontal starch gel electrophoresis, and qualitative morphological characters. Distributional data are utilized in conjunction with the proposed phylogeny to investigate speciation events in the group. The principal speciation mechanism is allopatric, brought about by vicariance across the lowlands of southeastern Arizona: the Cochise filter barrier. The area taxon relationships are compared with other groups. Vicariance via this mechanism is compatible with sister taxon pairs in other carabid genera, as well as in numerous vertebrate groups. Based on an electrophoretic clock, calibrated using data from Drosophila, the group began radiating 6-12 million years b.p. Timing of subsequent speciation events can be correlated with what is known of past climatic oscillations.

R1.5.  
6

EVOLUTION OF ELYTRAL SCULPTURE IN THE TRIBE GALERITINI  
(COLEOPTERA: CARABIDAE)

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Canada T6G 2E3

A reconstructed phylogeny, based primarily on structural features other than details of the elytral cuticle, provides the basis for inferring evolution of macrosculpture and microsculpture of the elytra of Galeritini. Macrosculpture consists of an alternating system of linear depressions (interneurs) and elevations (intervals). A transformation series extends in the subtribe Galeritina from primary intervals that are broad and slightly convex to costate to carinate, with or without development of secondary intervals. In the monobasic more primitive subtribe Planetina, the elytra have developed carinate primary and secondary intervals independently of these features in the more highly evolved groups of subtribe Galeritina. Within some taxa of Galeritina, the secondary intervals have been reduced or lost. The sculpticells of the microsculpture system, which are believed to reflect the underlying living cuticular cells, exhibit in the Galeritina two transformation series: one, from isodiametric to elongate; and a second from isodiametric to transverse. The biological significance of these transformation series is unknown, though the transverse form is generally correlated in other carabids with life in tightly-packed, wet leaf litter.

R1.6.  
1

CLASSIFICATION AND PHYLOGENY OF THE FAMILY APHELINIDAE  
(HYMENOPTERA: CHALCIDOIDEA)

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The subdivision of an economically important parasitic family Aphelinidae into subfamilies and tribes as adopted by earlier authors is discussed. six subfamilies and seven tribes, viz., Eriaporinae (Eriaporini and Myiocnemini), Coccophaginae (Coccophagini, Azotini and Prospaltellini), Aphelininae (Aphelinini and Aphytini), Pteroptricinae, Eretmocerinae and Calesinae are recognized in the family Aphelinidae. Number of tarsal segments, presence or absence of speculum on fore wings, presence or absence of thick setae on venation of fore wings and curved or straight condition of fore tibial spur are taken as subfamily characters; divided or undivided condition of pronotum and prepectus, presence or absence of post-axillae on mesonotum, presence or absence of thick setae on outer margin of hind tibiae are suggested as stable tribal characters; condition and number of antennal segments, condition of body and condition of fore wing venation are regarded as useful generic characters.

Phylogeny is based on primitive and advanced characters. On this basis the tribe Myiocnemini is regarded the most primitive and probably evolved from Euryischid-like ancestor, Eriaporini is also primitive representing an off shoot of the former. The subfamilies Coccophaginae and Aphelininae have evolved independently from the tribe Eriaporini. The subfamilies Pteroptricinae and Eretmocerinae are probably evolved from the tribes Prospaltellini and Aphelinini respectively. Finally, Calesinae is assumed to be an off shoot of Pteroptricinae and the most highly evolved subfamily of Aphelinidae.

R1.6.  
2

## GENERIC CLASSIFICATION OF OPIINE BRACONIDAE (HYMENOPTERA)

ROBERT A. WHARTON

There are approximately 1500 described species of opiine Braconidae. There are 3 tribes (excluding Gnaptodontinae) and 24 genera. The majority of the species (about 1000) are currently placed in Opius. Opius has 36 subgenera. Rearrangements of the existing classification are suggested on the basis of biology and morphology. The current tribal classification is artificial, and should be revised. Several subgenera are based on sculptural characters which are intraspecifically variable; and more stable features are offered for their characterization.

R1.6.  
3

## A REVIEW OF THE TRIBE TRYPHONINI IN THE ORIENT (HYMENOPTERA : ICHNEUMONIDAE)

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The ichneumonid tribe Tryphonini is a predominantly Holarctic group; most species occurring in Eurasia and in North America. A few genera are also exclusive to the Ethiopian (**Ibornia**) or the Neotropical (**Chiloplatys**, **Leviculus**) regions. Only two genera, with one species each [**Ctenochira pallipes** (Cameron) and **Dyspetes** sp. (= **D. praerogator** of Morley, 1913, misdet.) were reported from the Orient by Townes, Townes & Gupta, 1961.

The known hosts are the larvae of saw flies. The eggs are stalked and deposited on the larvae. They develop as exoparasites within host cocoons.

During extensive surveys for Ichneumonidae in India (1962-80) and in Orient, very few specimens of Tryphonini turned up, from higher elevations in Himalaya. The specimens represent 5 genera and 8 species. Three genera are reported for the first time from India with one new species each (**Tryphon**, **Cosmoconus** and **Polyblastus**). **Dyspetes** is represented by three species: **D. indicus** and **D. flavus** described as new by Gupta (1983), and a subspecies of **D. orientalis** Kasparyan also recorded from Kumaon Himalaya. **Ctenochira** is represented by **C. pallipes** and a new species from Dalhousie Himalaya. The new species are being described. Table I summarizes the world distribution of the genera of the Tryphonini

R1.6.  
4

THE FIRST FEMALE PLUMARIIDAE (HYMENOPTERA:  
CHRYSIDOIDEA) FROM SOUTHERN AFRICA

DENIS J. BROTHERS

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The aculeate family Plumariidae has a disjunct distribution and comprises five genera, Plumarius and Plumaroides in the deserts of western South America, Myrmecopterina and Myrmecopterinella in the deserts of western Southern Africa, and Heterogyna in the Levant. Only males were known until recently, and even now there is no direct evidence that the females attributed to the family really belong there. (The first putative female was described in 1967 from specimens collected under stones in Peru.) Superfamily placement of the Plumariidae rests heavily on the presence of a specialised modification of the sting, so that any evidence which corroborates the association of these females with the males is important. The recent discovery of a few female specimens which are very similar to the specimens from Peru and which were collected in pitfall traps in Namibia (at the same locality as several males of Myrmecopterina) and Botswana, and which are of an appropriate size, is significant further evidence that the association is correct. The morphology and classification of the family is briefly discussed in the light of this discovery.

R1.6.  
5

AREA TYPES IN AFRICA SOUTH OF THE SAHARA

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During a revisional work of the Afrotropical Mutillidae a very rich material has been examined. To the results of our own 13 years collecting in Cameroun (1962 - 1975) providing 120.000 specimens, including 420 different species, 250 of which were new, and belonging to 37 genera and 7 subfamilies, have been added the necessary types and other specimens identified by former students as well as many unnamed African Mutillidae received for study from more than 80 museums and private collections.

As a result of this extensive study, which is still in progress, new sex combinations concerning species and genera of these insects characterised by an extreme sexual dimorphism have been established, new genera have been erected, the number of species in the majority of the revised genera has been doubled and many new morphological data important in taxonomy have been discovered. But of a particular interest was the possibility to draw up distribution areas of a series of species widespread in the continent. These areas, determined by geohistorical as well as by recent factors, may be of a general significance for animal and plants, resulting in areal types in the African continent.

**R1.6.** SOME ASPECTS OF THE ORIGIN OF LONG-TONGUED BEES  
**6** (APOIDEA: HYMENOPTERA)

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It has been considered so far that long-tongued bees originate from an andrenid (Pangurinae branch) rather than from a melittid line (Michener, 1944, 1974, Stephen et al., 1969).

However, our results based on the comparative-morphologic study of mouth parts, leg structures, female terminalia as well as morphologic and morphometric analyses of the wings of 62 species of 57 genera of bees indicate that long-tongued bees might have arisen from a primitive melittid rather than from an andrenid branch. As the greatest number of common characteristics of long-tongued bees and melittids is met in the subfamily Ctenoplectrinae, we suppose that long-tongued bees originate from the early Ctenoplectra-like ancestor.

**R1.6.**  
**7**

Title of the presentation: " Cladistic relationships of  
the Panurgine Bees "

Abstract: The cladistic analysis of the genera of the sub-family Panurginae (Apoidea - Andrenidae) reveals that this is a monophyletic group sensu Hennig.

Possible origins of this largely New World group of short-tongued bees are suggested along with biogeographic considerations.

Some panurgines show surprising convergences to the long-tongued bees.

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**R1.6.** The antennal Sensilla of the Plathythyreini (Ponerinae)  
**9** in comparison to those of other ants (Hym., Formicoidea)

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On the basis of the results of comparative studies with SEM and TEM of the antennal patterns of sensilla of 15 species of the Plathythyreini (Plathythyrea, Probolomyrmex), numerous species from all subfamilies of the ants, and additionally of a great number of species from the other superfamilies of the Aculeata, we can state that Plathythyrea lamellosa ROGER shows the most primitive pattern of sensilla of all ants studied up to this moment. There exist strong indications of a close phylogenetic relationship between the Formicoidea and the Scolioidea including the Scoliidae. Four different subcharacters in the pattern of sensilla of P. lamellosa support this assumption. The genus Probolomyrmex is doubtlessly closely related to Plathythyrea. Further studies are necessary to clarify whether the Scolioidea alone form the sister group of the Formicoidea.

**R1.7.** THE ROLE OF BERINGIA AS EXEMPLIFIED BY THE ZOOGEOGRAPHY OF  
**1** THE NEPHROTOMA DORSALIS SPECIES-GROUP (DIPTERA: TIPULIDAE).

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The dorsalis species-group within the Tipulid genus Nephrotoma has a monophyletic origin and consists of 46 species and subspecies, distributed throughout the Holarctic: 18 taxa are confined to the Nearctic, 26 to the Palaearctic and two species possess a Holarctic distribution. The origin of the group has to be found in the eastern Palaearctic region and dates back to the early Tertiary. Phylogenetic reconstruction on the basis of the male and female genitalia reveals that the species of the dorsalis group occurring in the Nearctic region do not have a monophyletic origin. This implies that more than once there has been an exchange between both continents by way of Beringia, where several times in the course of the geological history a landbridge existed.

An analysis will be presented of the zoogeographical development of the dorsalis species-group, based on a profound phylogenetic reconstruction. A comparison will be made with other taxa having a similar distribution and the results will be discussed within a larger biogeographical context.



## R1.7. 2

### MOSQUITO FAUNA OF IRAN

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For the first time, a comprehensive study on the mosquito fauna of Iran and the temporal and spatial distribution of Iranian mosquitoes has started since 1980. In this program in which 60000 mosquito larvae as well as several thousand adults have been examined, the total of 55 mosquito species in 6 genera have been found. Twenty species of Anopheles, 10 Aedes, 20 Culex, 1 Coquillettidia, 3 Culiseta and 1 Uranotaenia constitute this faunal list. These species represent Palearctic, Ethiopian as well as Oriental elements.

## R1.7. 3

### MARINE MIDGES (CHIRONOMIDAE: TELMATOGETONINAE): A SYSTEMATIC REASSESSMENT

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Chironomid midges are amongst the most diverse and numerous insects in the marine intertidal zone, although they are often overlooked by entomologists and marine biologists. These marine midges belong to two distinct lineages, one related to the terrestrial genera centred on Smittia, subfamily Orthocladiinae, the other comprising the subfamily Telmatogetoninae. This subfamily, the subject of the present study, is restricted to marine habitats throughout the world, except where the genus Telmatogeton has diversified into Hawaiian freshwater streams and torrents. Detailed examination of the larvae and pupae of the Holarctic species of Telmatogetoninae has led to a reassessment of the supra-specific classification. However, the immature stages, particularly the pupa, confirm the isolated position of this enigmatic subfamily previously proposed for the aberrant imagines.

**R1.7.** PHYLOGENY AND BIOGEOGRAPHY OF NET WINGED MIDGES OF GENUS  
**4** BLEPHARICERA (DIPTERA : BLEPHARICERIDAE)

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The Holarctic genus Blepharicera is shown to be the monophyletic sister group of the European genera Dioptopsis and Liponeura. Within Blepharicera, the Oriental apoana-group appears to be an early side branch of evolution. The East Nearctic simulans-group is also primitive but more closely related to the West Nearctic and Palearctic group of derived species. These are distinguished by, e.g., the rotation of their hypopygial skeleton. The more primitive members of this group occur in western North America and in East Asia, suggesting former circumpacific connections via Beringia. Of the subgroups in this complex the Japanese Parablepharocera are one; hence, they merit no generic status. The most derived subgroup is restricted to the Palearctic Region, mainly to Asia. A single species, B.fasciata, the type species of the genus, has reached Europe. It extends from West Asia through the Mediterranean Region to the west of Europe. The Blepharicera on both sides of the Atlantic Ocean are therefore quite unrelated and, contrary to previous opinions, provide no evidence for former transatlantic land connections.

**R1.7.** NEOTROPICAL BLEPHARICERIDAE--PRESENT STATE OF TAXONOMIC  
**5** AND BIOGEOGRAPHIC KNOWLEDGE

CHARLES L. HOGUE

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The Blephariceridae ("net-winged midges") of the neotropics remain the most poorly known of those of all the zoogeographic regions. Presently, there are 62 names recognized that would represent 25% of the world fauna if all are found valid. Many in Kelloggina may be synonymized, but their number will surely be replaced and even surpassed by new species in other genera, especially Limonicola, a considerable number already residing in the author's collection. The area's fauna is certainly of austral derivation. The most primitive genera conserve a limited, very southernly distribution. Others have dispersed along the Andean Cordillera and circumcaribbean mountains through the Antilles and to northern Mexico. A barren zone beyond in Mexico separates the Nearctic fauna. These dipterans presumed rare previously may be collected with facility when conditions are correct.

R 1.7.  
6

MATING TROPHALLAXIS IN DIPTERA

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"Mating trophallaxis" is defined as: "trophallaxis between mates, connected to copulation and taking place shortly before, during or after copulation." Its different forms are known in species of the families Tephritidae, Platystomatidae, Micropezidae and Sciomyzidae, and have recently been found also in species of Asteiidae. Pre-mating trophallaxis is known in all the above mentioned families with the exception of the Platystomatidae and assumes two main forms. In one form the trophallactic substance is secreted through the male's proboscis and is deposited on the substrate. The feeding female become receptive to the male and continues feeding during copulation. In another form the male secretes a droplet or a bubble which is transferred directly to the female's proboscis as part of the courtship. In-mating trophallaxis is known in the Platystomatidae. The males of several species were observed "stretching forward" over the female's head and "kissing" the labella of her lifted proboscis. An exchange of substance takes place during this process. Post-mating trophallaxis is known in several species of Tephritidae, and this trophallactic phenomenon is usually associated with a marked dimorphism of the salivary glands. The evolutionary significance of mating trophallaxis is not well understood. Pre-mating trophallaxis is clearly associated with sexual selection. In-mating trophallaxis has been credited with the potential of ensuring insemination, but this needs yet to be proven. Post-mating trophallaxis has not yet been adequately explained.

R 1.7.  
7 EVOLUTION WITHIN THE GENUS LONCHOPTERA  
(DIPTERA: LONCHOPTERIDAE)

HUGO ANDERSSON

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The spear-winged flies (Lonchopteridae) form a small and well-defined group (Acroptera) within the higher flies (Diptera Cyclorrhapha). The family has been treated as a sister group to all other families of Cyclorrhapha (Atriata) (Griffiths, 1972:67), which means that Acroptera has existed for the millions of years during which the hundreds of families of Atriata differentiated.

The distribution and morphology of most of the about 40 known species have been studied. Especially the male genitalia, abdomen and legs are structures that have made a phylogenetic analysis possible. The differences in the male genitalia are so profound that the genus has been divided into 8 genera. The reconstructed phylogeny has been compared with the present distribution and with earths history.

**R1.7.** SEASONAL CHANGES OF CHROMOSOME INVERSIONS OF THE NATURAL POPULATION OF  
**8** DROSOPHILA ALBOMICANS DUDA IN WULAI, TAIPEI, TAIWAN

FEI-JANN LIN<sup>1</sup> and HWEI-YU CHANG<sup>2</sup>

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The relationship between the chromosomal inversion polymorphisms in the natural population of Drosophila albomicans and its climatic factors, temperature, precipitation and relative humidity, in Wulai, Taipei, Taiwan has been observed from April 1977 to March 1978. The flies were collected from Wulai and iso-female stocks were established in the laboratory. The polytene chromosomes of F<sub>1</sub> larvae were detected and their heterozygotic inversions were observed and recorded. Total of 86 inversions were observed. Of which, In(2L)B<sub>1</sub>D<sub>5</sub> shows the highest in its frequency (41.91%), and In(1)A<sub>1</sub>A<sub>4</sub> the next (6.95%). There are also statistically significant on the changes of inversions due to the environmental fluctuation. Those are In(1)A<sub>1</sub>A<sub>4</sub>, In(1)A<sub>5</sub>B<sub>5</sub>, In(2R)A<sub>1</sub>A<sub>5</sub>, In(2L)B<sub>1</sub>D<sub>5</sub>, In(3)A<sub>1</sub>B<sub>1</sub>, In(3)A<sub>1</sub>C<sub>3</sub> and In(3)M<sub>5</sub>O<sub>4</sub>. Based on correlation analysis, the frequencies of In(2L)B<sub>1</sub>D<sub>5</sub>, In(1)A<sub>1</sub>A<sub>4</sub> and In(1)A<sub>5</sub>B<sub>5</sub> show negative correlation with temperature, and possitive correlation with relative humidity, while only In(2L)B<sub>1</sub>D<sub>5</sub> shows possitive correlation with precipitation. The rest of the inversions detected have no correlation with climatic changes so far observed during the experimental period. The results revealed that In(2L)B<sub>1</sub>D<sub>5</sub>, In(1)A<sub>1</sub>A<sub>4</sub> and In(1)A<sub>5</sub>B<sub>5</sub> have a close relationship with temperature, precipitation and humidity. In other word, the adaptiveness of In(2L)B<sub>1</sub>D<sub>5</sub> dues cold temperature, lower relative humidity and dried environment, whereas In(1)A<sub>1</sub>A<sub>4</sub> and In(1)A<sub>5</sub>B<sub>5</sub> show co-adaptiveness for cold weather, higher relative humidity and no relationship with precipitation at all.

**R1.7.**  
**9**

A NEW ACALYPTRATE FLY FROM SOUTHERN AFRICA,  
POSSIBLY REPRESENTING A NEW FAMILY

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The life history, including descriptions of egg and larval stages, of a new, predominantly winter, grassland fly is presented. Taxonomic relationships, based on adult and larval characteristics, are discussed with reference to other acalyptrates. The adults are unique in possessing two extra pairs of bristles adjacent to the anterior fronto-orbital bristles. The peculiar, amoeboid larvae, superficially resembling those of Platypezidae, appear to graze on microflora of decaying grass and can resist considerable desiccation. Familial affinities appear to be with the Heleomyzidae, Chyromyidae, and possibly the Lauxaniidae, but exact placement is still uncertain.

**R1.8.**  
**1** PHENOLOGY OF THE HYPERPARASITIDS OF THE PEA APHID IN  
ALFALFA FIELDS IN NEW JERSEY (USA)

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Bronx, New York 10458 (USA)

Field sampling of the pea aphid, Acyrtosiphon pisum (Harris) was conducted to determine the seasonal fluctuations and degree of parasitization by its primary parasitoids and hyperparasitoids. This three year study indicated that the average degree of parasitization was 64.7%, with a range of 46% to 71.8%. The field-collected mummies were held in the laboratory and the overall adult emergence results were: primary parasitoid (Aphidius ervi) 54.2%; and the hyperparasitoids were 45.8%. Of the hyperparasitoids, Dendrocercus carpenteri was the most abundant (64.7%) followed by Asaphes lucens (32.2%), Alloxysta sp. (2%), and Aphidencyrthus aphidivorus (1.1%). The ectoparasitic or "direct" hyperparasitoids (96.6%) were more abundant than the endoparasitic "indirect" hyperparasitoids (3.1%). The sex ratios were as follows: of the 2,603 Aphidius 1 male:1.26 female, of the 1,425 Dendrocercus 1 male:1.75 female, and of the 712 Asaphes 1 male:3.75 female.

**R1.8.**  
**2** EVOLUTIONARY ASPECTS OF LARVAL FOOD-PLANT EXPLOITATION IN MICRO-  
LEPIDOPTERA: AN ECOLOGICAL APPROACH TO PHYLOGENETIC DATA

J. J. BOOMSMA  
Department of Animal Systematics, Vrije Universiteit, Amsterdam

With regard to larval food-plant exploitation in microlepidopteran families, a clear tendency towards more polyphagy and less endophagy can be observed when following the phylogenetic tree. Most leaf-mining families are primitive and particularly associated with woody food-plants. An increasing use of other than Rosiflorae food-plants seems to be the prevailing evolutionary trend in Ditrysian microlepidoptera. The origin and evolution of microlepidopteran food-plant niches is discussed, with particular reference to recent literature on the phylogeny of microlepidopteran families and the systematics of higher Angiosperm taxa.

R1.8.  
3

Phenology of *Sciomyzidae* (Diptera) in a mediterranean forestry biotop.

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Six species of *Sciomyzidae* can be found in the oak grove of Rochefort du Gard, sited in the South of France.

These are : *Trypetoptera punctulata* (Scopoli), *Coremacera marginata* (Fabricius) *Euthycera cribrata*, *E. leclercqi* Vala et Reidenbach, *Dichetophora oblitterata* (Fabricius), and *Pherbellia cinerella* (Fallen), occasionally *E. alaris* Vala et *Salticella fasciata* (Meigen) can also be captured.

This study enables to precise :

- . the seasonal variations of the species
- . the synchronism between breeding of 3 species and the one of their Molluscs-prey.
- . the phenological periods of each species determined by the presence of larval instars, pupae, adults and preoviposition period. *P. cinerella* only is univoltine. Other species present only one annual generation whose emergence comes in the Springtime. Oviposition starts in the Summer and larval cycle which partially takes place in the Winter is followed by a diapause of the pupae until the end of May.

R1.8.  
4

PROSPECTS OF PIPUNCULIDS (DIPTERA:PIPUNCULIDAE) AS BIOCONTROL AGENTS OF LEAFHOPPER (HOMOPTERA) PESTS

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So far 62 pipunculid species have been discovered associated with a number of leafhopper pests all over the world. Besides, the flies also attack other hoppers. These flies have successfully checked the population of various leafhopper pests of sugarcane, rice, mango, etc. in U.S.A., Japan, and the Oriental region. In India, only Pipunculus annulifemur had been reported parasitising the mango hoppers. Recently, two pipunculid species, Tomosvaryella nitens and a new species close to the former, have been/to be closely associated with the rice leafhoppers in Ludhiana, India. There seems to be great scope in the suppression of the rice leafhoppers through these biocontrol agents.  
/found

R1.8.  
5THE EPIZOOTIOLOGY OF NPV OF THE INDIAN MOTH LYMENTRIA  
OBFUSCATA WALK

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A Nuclear polyhedrosis virus (NPV) isolated from the field infected late instar larvae of Lymentria obfuscata a defoliator of deciduous fruit and forest trees was propagated on laboratory maintained II and III instar larval cultures at  $25 \pm 5^\circ \text{C}$  and 16:8(L:D) photophase on the host foliage sprayed with  $3.5$  and  $5.0 \times 10^6$  PIB/ml Yielded  $3.5 \times 10^8$  PIBs/larva. Field dissimulation of these viral concentrations prevented defoliation and resulted 95% pest population collapse. LC increased from  $2.5$  to  $5.0 \times 10^6$  PIBs from II to IV instar and was invariably proportional to the increase of larval body weight from 25 to 150 mg.  $5 \times 10^6$  PIB, 10 days and  $25 \pm 2^\circ \text{C}$  were evaluated as LD, LC, LT, 90,s and optimum temperature respectively for the disease development and mortality. The NPV persisted at high levels in the host's habitate, remained latent during winter upto  $-10^\circ \text{C}$  and the virulence became apparant with the increase of external stresses of humidity, temperature and food scarcity during the period of population eruption.(Spring and early summer).

W1.1. STRUCTURE OF THE MALE POSTABDOMEN AND A SYSTEM OF  
7 CHLOROPOIDEA (DIPTERA, SCHIZOPHORA)NARTSHUK EMILIA ZOOLOGICAL ISTITUTE ACADEMY OF SCIENCES OF  
THE USSR 199034 LENINGRAD USSR

Use of features of the male postabdomen and the genitalia proper proved fruitful to clarify a suprageneric system in Chloropoidea. Asymmetrical postabdomen, different number of sclerites in it together with other morphological features permit to confirm Siphonellopsidae as a separate family. Therefore Chloropidae s. str. receives more definite morphological diagnosis. Progressive ecological specialisation, larval phytophagy on Monocotyledons, evolved only in Chloropidae s.str. Subfamilies of Chloropidae: Rhodesiellinae, Hippelatinae, Oscinellinae and Chloropinae are defined by the male postabdomen and genitalia as well. Definite differences in the male genitalia (discrete, fused or absent cerci, discrete or fused with epandrium surstyli, disposition of gonites etc.) are found at the level of tribes or genus groups especially in subfam. Chloropinae



W1.1. PROBLEMS OF THE KARYOTAXONOMY OF A GENUS OSCINELLA  
9 (DIPTERA, CHLOROPIDAE)

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The paper presents data of the karyotaxonomy of five species of the Genus *Oscinella* (*O. frit*, *O. hortensis*, *O. pusilla*, *O. nigerrima* and *O. maura*). Only *O. maura* is a species with distinct morphological features the others are very similar and manifest a great variability. The Karyotype is used for different taxonomical solutions. The Karyotype of *O. frit* is identical with those of *O. hortensis* ( $2n=6+neoXY$ ). *O. nigerrima* included two forms: one's with a Karyotype of *O. frit*, other's - with  $2n=6$  (*Oscinella* sp.). On the basis of the karyological data it is supposed that *O. frit* is a very polymorphic species included features of *O. hortensis* and *O. nigerrima*. It is suggested new taxonomical features for *O. frit*. The karyotypes of *O. pusilla* ( $2n=6+XY$ ) and *O. maura* ( $2n=6+OX$ ) are well distinguish from those of *O. frit*. It is discussed the evolution of these species.

W1.1. PHYLOGENY OF LIPARA MEIGEN BASED ON BIOLOGICAL EVIDENCES  
11

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The phylogenetic relationships of the genus *Lipara* Meigen, comprising nine described species, are considered in taking a serious view of biological evidences as well as general morphological characters of egg, larva, and adult. Biological evidences here adopted are life-form, especially the feeding behavior of larva, and premating signals of adult male. These characters are related to the specific stages, that is, gall formation, body size, and consequently physical properties of vibration signals. The species groups obtained are in order of age of deviation, *pullitarsis* group (*pullitarsis* Doskočil et Chvála + *frigida* Kanmiya), *rufitarsis* group (*rufitarsis* Loew + *aino* MS), *similis* group (*similis* Schiner + *vallicola* Kanmiya), and *lucens* group (*lucens* Meigen + *baltica* Karpis + *japonica* Kanmiya + *brevipilosa* Nartshuk). The possible branching of the stem species of the four groups are due to climatic events, because four groups have respective life-form which is closely associated with reed development.

## W 1.1. BIOLOGY OF FRIT FLIES IN AGRICULTURAL GRASS IN DENMARK

12

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ZOOLOGICAL LABORATORY, UNIVERSITY OF AARHUS, DENMARK

In agricultural grass in Denmark Oscinella frit (L.) and O. pusilla (Mg.) are predominant species of stem boring Diptera; in some sites O. vastator (Curt.) is abundant. O. frit is numerous in most grass areas, but apparently perennial pastures are less attractive for oviposition than annual and mown grass. O. pusilla is especially abundant in perennial pastures, rather common in perennial mown grass fields, but few in numbers in annual and newly sown grass. In contrast to O. frit, O. pusilla and O. vastator seem to be stationary species not taking off regularly; the latter species often build up local populations in perennial grassland. In Denmark there are three annual generations of O. frit, in some years the third generation is partial. Apparently, in Denmark the annual temperature sums are close to the values required for the completion of three annual generations.

## S 1.2. THE NEED FOR RECOGNITION OF THE IMPORTANCE OF RESEARCH IN SYSTEMATIC ENTOMOLOGY

1

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One of the fundamental scientific insights emerging from systematic entomology is that the insect and arachnid species of the world vastly outnumber all other living animals combined, and that only a small fraction of the total number have even been described. These enormous numbers of species mean that insects and arachnids permeate the diverse and essential processes that help to make the natural world function as a self-sustaining biological system; support systems of the planet are threatened by the unprecedented, and growing, impact of the human species. The need for recognition of the importance of new research in systematic entomology rests solidly on the necessity to understand how biological ecosystems function and what species of organisms are involved in making them function. This information is crucial to the management of renewable natural resources and to the long-term ecological stability of the world.

## S1.2. 2

### IDENTIFICATION SERVICES

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National and international insect identification services will be reviewed on a world basis and the future needs for authoritative identifications, based on sound taxonomic research, will be assessed. In agricultural entomology the maintenance of identification services for plant quarantine, integrated pest management and biocontrol of pests and weeds requires long-term planning and funding and there are similar needs to support taxonomic identification services in medical entomology and in other areas of entomological research, especially for faunistic surveys, ecological investigations, biogeographical analyses and studies of insect diversity.

## S1.2. 3

### NATURE OF AND QUALITY OF THE RESEARCH BASIS REQUIRED FOR BIOSYSTEMATIC SERVICES.

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The Research Basis is defined as complex of: Research Staff, Research Collection, Libraries and Files, Technical Equipment, and, Experience and Technological Knowhow. To provide high quality services the Research Basis must be developed, perfected and maintained permanently ahead of the needs. The present Research Basis should also generate new regional centres of taxonomic services (e.g. in the Third World). The quality of Research Basis is determined by the size and maturity of the research collection and experience of the research staff. Worldwide integration of taxonomic resources (collections, documentation, technology transfer) is essential for highest quality of biosystematic services.

## S1.2. AVAILABILITY OF TAXONOMIC SPECIALISTS

4

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Effective research and action programs in basic and applied entomology demand a sound taxonomic base. Authoritative identifications of many taxa are difficult or impossible to obtain today. Current taxonomic services in the public and private sectors are reviewed. Sources of personnel providing these services are discussed. Projections are made of the future availability of specialists. Recommendations are made to assure the availability of qualified systematists in critical taxa. Methods of assessment of taxonomic needs and of specialists supplying these needs are described.

## S1.2. LITERATURE RESOURCES

5

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Like insects themselves, biosystematics literature is scattered, diverse and prolific. Although its users are increasingly well served by publicly available bibliographic databases, many otherwise 'computer-literate' entomologists have failed to appreciate the value of these systems. In the less developed countries, computer searches are generally either unknown or simply dismissed as being too expensive, although they are often highly cost-effective and may be the only means of gathering essential information. No single centre can hope to identify, acquire and store all the literature, and where only basic resources are available it may be better to rely on the established indexing and abstracting services, backed up by document supply from a network of specialist centres. Greater international cooperation between such centres is needed to ensure the widest possible availability, knowledge and use of information services and literature resources.

## S 1.2. 6

### COLLECTION RESOURCES

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Insect collections are a vital world resource, a permanent record of insect life and laboratory of meticulously prepared, documented and catalogued specimens. Although specimens and taxa are seemingly countless, our great collection-oriented institutions presently contain only a fraction of the world's insect fauna. Confronted with such vast diversity, their economic impact and an almost overwhelming need for growth, as myriads of additional specimens and new taxa from geographically widespread regions are collected, effective use of collections demands our immediate attention. Methods to efficiently store, manage and retrieve this great diversity of specimens and information will be discussed and illustrated within the following outline: I. Categories of collections and their arrangement; II. Collection accessibility; III. Clientel; IV. Identification services; V. Collection policies.

## S 1.2. 7

### BIOLOGICAL SURVEYS

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National biological surveys that are devoted to or include insects are considered. Their history, current capabilities, and future plans and needs are summarized: different surveys differ very widely in their form and capabilities. Characteristics of selected surveys are reviewed in more detail, leading to some generalizations about the establishment and functioning of biological surveys.

S1.2.  
8

## ELECTRONIC DATA PROCESSING APPLICATIONS

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Automated Data Processing (ADP) offers the hope of truly mastering our information environment. The structure and flow of information in systematics are described. Systematics is data intense, but requires little mathematics. Its task is to name, describe, distinguish, and interrelate some 10 to 30 million or more arthropods. This information is generated and initially analyzed by the systematist. These are the characteristics of a data environment more similar to those of business than to those of the physical sciences or engineering. Business solves its problems by automating the data entry points. Systematics must do likewise. Computers for individual systematists at their work bench will greatly increase productivity. The benefits of such automation are documented by examples. Both the present and future (ideal) use of automation is illustrated by the ADP programs of the U. S. Department of Agriculture, Systematic Entomology Laboratory, and the Smithsonian Institution, Department of Entomology.

S1.2.  
9

## UNIVERSITY TRAINING OF SYSTEMATIC ENTOMOLOGISTS

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Knowledge of insect taxa ranges from rudimentary to highly advanced, a circumstance likely to be evident for another two centuries. This wide divergence requires collectively workers with a wide range of individual predilections and types of ability. To continue progress on a broad front, those in universities charged with education of systematists must be prepared to accept a correspondingly wide range of individuals as graduate students. Regardless of group studied and techniques required to deal with it, systematists-in-training ought to have the opportunity to become acquainted with a wide range of character systems and of methods of investigation. Nomenclature and curatorial work are common portions of most systematic studies, and principles and practice of such areas must be mastered. The notion that taxa are limited by systems of relationships (ontogenetic, tokogenetic, and phylogenetic) must be instilled. Study of palaeontology which address both practical and theoretical questions should be undertaken by all graduate students in systematics, for such work will improve ability to think in terms of temporal aspects of taxa. Field work is required, because taxa are parts of living systems, and a worker must become familiar at least to a limited extent, with living organisms of the taxa studied. Although intense interest in a taxon is virtually prerequisite to good systematic work, graduate students must be made to realize that positions available might require study of some other taxon than the one favored, and that they might have to switch interests.

## **S1.2.** THE NEED AND VALUE OF SHORT-TERM TRAINING COURSES TO SUPPORT **10** BIOSYSTEMATIC SERVICES

PAUL M. MARSH

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One of the most critical needs in any entomological research program is the provision of authoritative identifications of the insects and mites involved. Although the ultimate authority for these accurate identifications is a taxonomist, it is important and desirable for non-taxonomists to gain some knowledge of the classification and identification of the groups being studied in their programs. To this end, several international short courses have been developed, i.e., The Parasitic Hymenoptera and The Coccidology Training Sessions at the Univ. of Maryland, The Acarology Lab. Summer Courses at the Univ. of Ohio, and The Int'l. Course on Applied Taxonomy offered by CIE. A brief discussion of these and other courses will be presented including suggestions on format. Suggestions for the development of training in other areas of the world and in other insect and mites groups will be offered.

## **S1.2.** INTERNATIONAL TRAINING VISITS **11**

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The international nature of most taxonomic work and the world-wide dispersal of reference collections necessitates much international travel by taxonomists to gain experience of the insect groups on which they specialise. Contacts with institutions and individuals and exchanges of information are important throughout a taxonomist's career but especially during its early stages. A review of the various types of short and long term training visits currently available will be presented and possible methods of funding will be summarised.



S1.2.  
12

## TECHNOLOGY TRANSFER AND SPECIFIC NEEDS IN DEVELOPING COUNTRIES

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Biosystematic studies of insects necessarily involve the multi-dimensional concept of species, populations of which distributed in time and space, adapt to environmental challenges, very often resulting in large scale intraspecific diversity, direct or indirect leading to considerable taxonomic chaos. Consideration of species as biological systems has been made possible through adequate data based on eco-ethological, physiological, biochemical as well as biogeographic characteristics hinging principally on electrophoretic, SEM and computer methods. A wide gap however exists regarding the technological know-how regarding utilisation of different techniques particularly in the developing countries, where natural as well as man-made environmental changes exert a tremendous impact not only on species composition, behaviour and biology of insects, but also on the vector capabilities of many species of agricultural and medical importance, for which a correct diagnosis appears essential.

The need for technology transfer to developing countries would appear imminent to ensure a better understanding of taxonomic problems through creation of a centralised data bank system with appropriate programmes for retrieval of information, supported by a network system involving institutions dedicated to biosystematic studies of insects.

S1.2.  
13

## Pest Management

E. G. King, J. W. Smith, and G. L. Snodgrass

Integrated pest management (IPM) in today's agriculture requires a detailed and accurate knowledge of interactions between different elements in the agroecosystem. Proper identification is necessary during all phases of IPM research and practice because of the biological variation between species of both plants and animals. Expert systematists are needed to make the initial identification of species, write descriptions and form reference collections. General systematists and museum reference collections are needed to aid the researcher and IPM practitioner. During the research and developmental phase of IPM programs, voucher specimens of all research material is essential. Unfortunately, financial support for systematic research and collections has not kept pace with the rapid expanding field of IPM. A specific example of the systematic research effort involved in an IPM program is given for the optimum pest management program (OPM) that took place in Panola County, Mississippi in 1977-1980.

**S1.2.** THE IDENTITY OF SOME MYMARID AND TRICHOGRAMMATID PARASITIDS  
**14** OF LEAF AND PLANTHOPPERS.

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The fundamental problem that confronts an economic entomologist developing integrated pest control programme of rice pests is the identity of parasitoids involved. Two of the major pests of rice are the stem borer and leaf and planthoppers. Careful surveys of the rice growing areas and collecting reared as well as authentically labelled specimens of parasitoids must be planned and such a collection should be studied by specialists at a co-ordinated centre. A large number of mymarid and trichogrammatid parasitoids of leaf and planthoppers have been reared in the rice growing areas of the world, but their true identities have yet to be established. Girault described many species of these parasitoids from Australia and it is very difficult to recognise these from his very terse descriptions. Experience as well as recent studies have revealed that many Girault species are well distributed in the rice growing areas and the potential parasitoids have to be critically studied in the light of Girault's contributions before their identities are established. A list of mymarid and trichogrammatid parasitoids of leaf and planthoppers of rice and their synonymies is appended.

**S1.2.** REGULATORY/QUARANTINE NEEDS OF ACTION PROGRAMS  
**15**

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The movement of food, feed and fiber commodities within or between countries of the world is often predicated upon knowledge of the presence or absence of insect pests at the point of origin. The records of pest occurrence and/or timely, authoritative identification often are a basis for the allowance to move these commodities. Conversely, the lack of knowledge of occurrence or authoritative identification can result in an embargo or chemical treatment of commodities. The services of and research by systematists are essential to regulatory/quarantine programs from the stand point of legal, ethical, and biological considerations.

1  
S1.2. SPECIFIC NEEDS OF ACTION PROGRAMS: STORED PRODUCTS  
16

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The widespread prevalence of food shortages and the heavy losses imposed upon stored food by insect and mite pests lend a sense of urgency to any discussion of post-harvest pests. Precise identification of the offending arthropod is the only sure basis for any rational strategy of pest management. A new publication, *Insect and Mite Pests in Food: An Illustrated Key*, is being developed to facilitate identification of stored-food pests. It will be necessary to develop additional keys to include all of the insect and mite pests of stored products as well as any predatory or parasitic arthropods that might be used to control them. Administrative guidelines regarding insect and mite contaminants in food may have to be modified if biocontrol agents ever come into routine use to suppress pest populations in stored foods. Too little is known about the significance of intraspecific variants (biotypes) in pest populations and the threat they pose to stored products to provoke any drastic changes in quarantine regulations; however, the subject merits further consideration. Solutions to all of these problems and needs would be facilitated by the establishment of a database on stored-product pests. Pest managers faced with a difficult situation could quickly elicit helpful information about any pest in the database.

S1.2. SPECIFIC NEEDS OF ACTION PROGRAMS IN FORESTRY  
17

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It is easy for an entomologist to appreciate the importance of defining an insect taxon before it and its place in a forest ecosystem can be understood. Entomologists must learn, however, that it is not so easy for forest managers, for funding agencies, and for the many people working in forest entomology who are not trained entomologists. A few examples will be used to emphasize this critical point.

**S1.2.** BIOSYSTEMATIC SERVICES IN ENTOMOLOGY  
**18** SPECIFIC NEEDS OF ACTION PROGRAMMES IN ECOLOGY/ENVIRONMENT

PETER S. CRANSTON

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Ecological and environmental programmes are capable of generating enormous amounts of material requiring the expertise of the biosystematist. Several different currently used approaches to dealing with this burden are outlined and methods assessed in terms of their usefulness in communicating data to other scientists. It is concluded that a biosystematic input into ecological/environmental programmes should take place from the outset, since the biosystematist ought to have the general biological knowledge to advise on all aspects of feasibility. Furthermore, it is advocated that biosystematists, in selecting their research groups, should give a higher priority to meeting the demands for their expertise from ecologists and environmentalists.

**S1.2.** BIOSYSTEMATIC SERVICES NECESSARY FOR ACTION PROGRAMS IN MEDICAL AND  
**19** VETERINARY ENTOMOLOGY

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Sustained biosystematic services are necessary to support major action programs in medical and veterinary entomology throughout the world. In addition to rapid and accurate identifications at the species level, action and regulatory programs now require biosystematic services which are capable of characterizing and differentiating organisms at the population level. This is necessary primarily to support both the implementation of sophisticated control strategies and for epidemiological investigations of arthropod-borne diseases. Although traditional morphometrics continue to serve as a foundation for these services, scientists will have to incorporate new technologies into their biosystematic procedures. Such tools of biotechnology could include isoenzyme techniques, analysis of cuticular hydrocarbons, evaluation of mitochondrial DNA, utilization of monoclonal antibodies, and chromosomal characterization.

S1.2.  
20

## OPPORTUNITIES FOR IMPROVEMENT IN SERVICES AND RELATED RESEARCH - THE TAXONOMIST'S PERSPECTIVE.

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Limitations and needs for improvement in the amount and quality of service and preparation of supporting research are identified. Suggestions are presented for more efficient use of resources and for support by those who use the services. These include taxonomists' input in project planning and users' support in the preparation and publication of research results.

S1.2.  
21

## OPPORTUNITIES FOR IMPROVEMENTS IN OPERATIONS OF BIOSYSTEMATIC SERVICES

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The greatest potential for improving operations of biosystematic services lies in more effective use of the expertise of systematists, beyond doing identifications. Systematists are often in a strong position to anticipate problems and propose solutions in applied studies owing to our knowledge of morphology, relationships, life history and biology of target organisms. Scientists, employers and clients would all benefit from extended services based upon a collaborative biosystematic approach. Systematists should be encouraged to provide proactive and interactive services, helping to define and analyse problems, plan experiments, train personnel, assess alternative solutions, and evaluate results. New technologies, such as modern word processing and telecommunications equipment, permit cooperative establishment of comprehensive automated information systems to support services. Reports and catalogues can be regularly updated, produced and distributed throughout service networks. Support for improving biosystematic services will ultimately depend upon our success in identifying priorities and coordinating efforts to achieve beneficial results at both national and international levels. This will require regular formal consultation.

**§ 1.2.** BIOSYSTEMATIC SERVICES IN ENTOMOLOGY-  
**22** PROPOSED SOLUTIONS - INTERNATIONAL COOPERATION

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Improvements in the quality, kinds, and extent of international cooperation will provide important means of improving biosystematic services in individual countries and regions. For example, two priority activities in most nations/regions (foreign pest exclusion and biological control by introduced natural enemies) require information from outside the specific country/area and thus benefit from international cooperation. Direct scientist-to-scientist contact is essential for these activities, but improved planning for more comprehensive international programs is also needed. Communication among systematists and their professional organizations and between them and regional and international organizations is necessary. For these reasons, a continually updated database on available expertise should be maintained by an international agency. Short-term special training courses should be held in developing countries. Joint work on computerized databases of an international nature (e.g., taxonomic catalogs) will require broader EDP expertise. A new procedure for international oversight of systematics status and needs is required.

**§ 1.3.** STRUCTURE OF THE MALE GENITALIA AS AN AID IN THE SYSTEMATICS OF THE  
**2** TETRAPOLIPUS GROUP OF MITES.

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According to Berlese's definition of Tetrapolipus, the mites of the family Podapolipidae whose female has 2 pairs of legs should be placed in this genus. However, for some of these mites separate genera were established (Husband and Flechtmann, 1972; Feldman-Muhsam and Havivi, 1977), mainly in view of the shape of the male genitalia. Actually, in all these mites, the genital capsule of the male is placed on the dorsum, approximately at the same locus, near the anterior edge of the metapodosoma or on the tip of an anteriorly directed extension of the metapodosomal plate. In the different species, this extension overlaps the propodosoma a little or substantially, or even exceeds the gnathosoma. However, a decision as to whether the differences in the shape of the genitalia define species, sub-genera or genera, cannot be reached at present, since too few species of this group are known. A similar development in the position of the genital capsule exists also in the genus Podapolipus.

1

**S1.3.** INTEGRATED TAXONOMY ON DERMAPTERA 2  
**3** CHEMOTAXONOMIC AND CYTOTAXONOMIC INFORMATION

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Chemotaxonomic information integrates readily into the phylogenetic reconstruction between higher taxa levels of Dermaptera and Orthopteroidea. Four trace elements (Co, Cu, Mo and Ni) in hemolymph of Dermapterous and Orthopteroid insects were determined by flameless atomic absorption spectrometry. The contents of Cu in hemolymph of Dermaptera seemed higher than that of Orthopteroids and Dictyoptera values were the lowest and the analytical values fluctuated. The contents of Mo were 34 to 70 ppb. The difference in contents of Co and Mo were very small in Dermaptera and Orthopteroidea. In whole body-Ni, Orthopteroidea were lower than those of Dermaptera. Ni content of fat body of Dermaptera was more variable than Orthopteroids. Ni contents did not recognize the phylogenetic and geological trends. Electrophoresis pattern of esterase and hexokinase were analyzed among Dermaptera, Dictyoptera and Orthopteroidea for phylogenetic reconstruction. *Anechura harmandi* complex were compared on esterase activity. Remarkable difference between cyclolabidic *A.h.harmandi* and macrolabidic *A.h.lewisi* was not found except the allelic variation. Cytotaxonomic information of Dermaptera was listed. *Gonolabis marginalis* had N=12 and 13 chromosomes in the primary and the secondary spermatocytic divisions. From the results of chromosome observation on same Anisolabididae-sp., *Anisolabis maritima*, 2N=25 (22 autosomes + XXY sex chromosomes) in male germ-cell and 2N=26 (22+XXXX) were estimated.

Ref. SAKAI, Seiroku (1970-1983) Dermapterorum Catalogus Praeliminaris (I - XV)

**S1.3.** Plural origin of the male intromittent organ in  
**4** Heteroptera

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The family Enicocephalidae is a sister-group of the other Heteroptera. Its two most plesiomorphic subfamilies have quite different male genitalia. Those of Monteithostolinae have fused parameres, and a rich system of plates instead of a median phallus; some characters are reminiscent of the Auchenorrhyncha and adhere to the presumed heteropteran Bauplan. The genitalia of Aenictopecheinae have free parameres and a median phallus like other Heteroptera, but unlike them the phallus is external and permanently everted. Hence it is argued that the median phallus has evolved at least twice during the heteropteran phylogeny: once in Aenictopecheinae, and once or several times in Euheteroptera. Secondary male genitalia are present in some Schizopteridae.



### S1.3. MORPHOLOGIC-PHYSIOLOGICAL STUDIES ON PTEROSTICHUS

#### 5 "NIGRITA" (COL., CARAB.), A COMPLEX OF SIBLING SPECIES

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*P. "nigrita"* is comprised of three species, the biospecies *P. nigrita* Paykull 1790 and *P. rhaeticus* Heer 1837 and the morphospecies *P. mukdenensis* Breit 1933. This was determined by means of cross-breeding and morphological studies, especially of male genitalia. Males can be distinguished by the form of the right paramera and the preputional sac, females by the form of the sclerotized part of sternum eight or the sculpture of the elytral surface. Populations of *P. nigrita* and *P. rhaeticus* studied in the Rhineland differ in morphological, ecological and physiological properties, but are very similar with respect to rhythmic behaviour. Males of *P. nigrita* have  $2n=40$ , those of *P. rhaeticus*  $2n=46$  chromosomes. In one place in the Rhineland both species were found sympatric.

*P. nigrita* has a palearctic distribution, whereas *P. rhaeticus* is found only in Europe. This species forms a physiological cline from Swedish Lapland to Yugoslavia, as comparative studies showed. *P. mukdenensis*, formerly thought to be a subspecies of *P. nigrita*, is a valid species, endemic in the surroundings of Mukden, Manchuria.

### S1.3. STRUCTURE OF GENITALIA IN TAXONOMY OF TENEBRIONIDS

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Male and female genital external tract is studied in a great number of tribes and genus of Neotropical Tenebrionids. Particularly investigated are Epitragini, Stenosini (gen. *Rhypasma*), Pedinini and Opatrini coming from the Caribbean area, where many endemic genus and species are present due to the long isolation as well as some endemic genus and tribes of the southernmost part of South America, such as Nycteliini and Scotobiini. The main characters of the genital tract are used to try and establish the affinity (vs. divergence) among the different taxa (the only work so far existing on the female tract of S-American Tenebrionids being that due to Tschinkel & Doyen, 1980, 1982). Some rather good results have been obtained, which suggest to follow this line of research in taxonomy and phylogenesis of Neotropical Tenebrionids. Of course the examined characters may be used for the individualization of true OTU's, together with some other morphological characters studied by the author, such as the mouth parts of adult and the morphology of the larva of some species.

51.3. GENITAL STRUCTURE IN EXOPORIAN MOTHS AND THE LEPIDOPTERAN  
7 GROUND PLAN

NIELS P. KRISTENSEN

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The skeletomuscular ground plan of the genital segments of the lepidopteran infraorder Exoporia is assessed in the light of results from ongoing anatomical studies on Mnesarchaeidae and primitive hepialidae (Fraus). The exoporian genitalia are considered to be overall highly autapomorphic, and it is believed that they have little bearing on questions concerning the genital configuration of the lepidopteran ground plan. Inferences about the latter are discussed on the basis of recent studies on the non-neolepidopteran taxa.

51.3. VALUATION OF THE CHARACTERS IN THE STRUCTURE OF GENITALIA FOR TAXO-  
8 NOMY AND PHYLOGENY ON THE EXAMPLE OF THE PHYCITINAE (LEP.PYRALOID.)

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The genitalia structures of the Phycitinae are extreme polymorphic and allow no recognizable applicability for phylogenetic reconstruction at first sight. Sometimes we can recognize development rows of several structures in inferior categories as the genus. This is demonstrated with some examples.

For all that the Phycitinae are a very interesting examination object as nearly all Pyralidae groups, which momentary seem to be in a spontaneous continued development. The hitherto existing findings result in identical or similar parallel development rows, which we can only recognize with the application of above all habitual respectively all available characters, the more so as the structure of microelements just as the function of many parts of the genitalia structures are still insufficient or not at all known. Limited recognitions result only from the use of Character combinations of all available structures and not only from the genitalia structures alone.

### **S1.3.** MALE GENITALIA IN THE APHELINIDAE (HYMEN. CHALCIDOIDEA)

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D. BATTAGLIA

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Preliminary information is given on the results achieved in a comprehensive study of the male genitalia in the Aphelinidae. A number of variations have been observed in the structure of the copulatory organ among genera and species. Their significance in taxonomy and phylogeny is discussed.

### **S1.3.** FUNCTIONAL SOLUTIONS AND THEIR PHYLOGENETIC SIGNIFICANCE IN THE OVIPOSITOR OF DIPTERA; NEMATOCERA

CHRISTINE DAHL

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The functional morphology of the ovipositor from Trichoceridae, Tipulidae and Culicidae is studied and comparisons are made with other types of ovipositors in nematoceran families. Ovipositors of cretaceous trichocerid fossils are interpreted in relation to recent species. There exist several distinct functional solutions with special problems involved of non-homologous structures and their similar function. An evaluation of the mode of adaptation to special environmental oviposition conditions are made for several recent species. These are set against the more homologous male structures used for copulation and insemination. Possible pathways of adaptation for both sexes genitalia are pointed out and their evolutionary and phylogenetic significance are discussed.

### S1.3. IMPORTANCE OF MALE GENITALIA IN THE CLASSIFICATION OF

#### 11 PIPUNCULIDS (DIPTERA:PIPUNCULIDAE)

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Characterisation of Syrphoidea- group (Pipunculidae + Syrphidae), on the basis of wing venation and other morphological characters, has been adjudged drastically insufficient to demonstrate its monophyly. This necessitates the study of male genitalia and other accessory structures in detail. The features which support monophyly are- (1) absence of prominent macrochaetae on frons; (2) assymetrically deflection of 6th and 7th abdominal segments towards left side, with sterna larger than terga; (3) 8th abdominal segment terminal and strongly assymetrical; (4) at rest strongly deflexed and directed anteriorly, apposed against right side of protandrium; and (5) ejaculatory apodeme free. Male genitalia together with accessory structures and trochanter have been greatly manipulated in the classification of pipunculids. These characters have shown sufficient consistency and remained less influenced by the environmental conditions. Male genitalia alone has been found quite useful in the segregation of various species. The main characters used in the classification are those of fifth tergum, epandrium and surstyli. The shape and size of epandrium and surstyli are of great taxonomic importance.

### S1.3. CLASSIFICATION AND PHYLOGENY OF THE SUPERFAMILY

#### 12 EMPIDOIDEA (DIPTERA)

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The family Empididae, in the broad sense since Schiner, is regarded as an unnatural paraphyletic unit and is divided into four distinct families, forming together with the Dolichopodidae the superfamily Empidoidea. The new classification is based on the comparative holomorphological method and is supported by a study of the known extinct forms, including the presumed evolution of the feeding, mating and swarming habits of recent forms. The whole Eremoneura (Empidoidea + Cyclorrhapha) are thought to have evolved along two phylogenetical lines. One line with discrete lateral gonopods on male genitalia led to the Empididae of the new conception, the second line with a periandrium (the epandrium having been lost) was obviously a more progressive one. The original forms with symmetrical male genitalia led to the Atelestidae and Cyclorrhapha which differentiated in the early Cretaceous period. The other forms are characterized by apomorphous asymmetry of the male genitalia and this line had again bifurcated during the Lower Cretaceous period to produce the recent Hybotidae and the "microphorid" line, forming a monophyletic subgroup of the Microphoridae and Dolichopodidae.

W1.4.  
1

BIOECOLOGICAL AND BEHAVIOURAL ASPECTS OF SOME SPORO-  
PHAGOUS TUBULIFERA (THYSANOPTERA:INSECTA) FROM INDIA.

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Diversity spectrum in relation to the range of fungal species consumed, the incidental impact of feeding on the reproductive biology of sporophagous species such as Loyolaia indica, Priesneriana kabandha, Ethirothrips agasthya, Elaphrothrips denticollis, Mecynothrips simplex, Tiarothrips subramanii etc., and the adaptational trends associated with feeding as indicated by SEM studies are highlighted. The fungal resource availability for feeding both in aggregating and solitary species of sporophagous thrips at their specific niches, and their impact on dispersion in species like Priesneriana kabandha and Loyolaia indica are also discussed, along with the behavioural aspects of some sporophagous species.

W1.4.  
2 THE FINE STRUCTURE OF THE SCOLOPOPHOROUS ORGANS IN THE  
PEDICEL OF THYSANOPTERA

BODE, W.

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The fine structure and arrangement of the scolopidia in the pedicel of the Thysanopteran genera Thrips, Aeolothrips and Haplothrips is surprisingly uniform, although these genera belong to three families with considerable morphological differences (Thripidae, Aeolothripidae, Phlaeothripidae). In general, 32 scolopidia were seen in each pedicel. There are five groups (scoloparia) of five scolopidia and one group of six scolopidia, which belong to the Johnston's organ. In contrast to the typical structure known from most other insects, ten scolopidia of Johnston's organ in Thysanoptera have not three, but only two sense cells. Four of these scolopidia show two ciliary processes of the "thin" type, six of them have one cilium of the "thin" and one of the "thick" type.- Although amphinematic scolopidia are characteristic for Johnston's organ, two of the examined scoloparia in Thysanoptera contain one mononematic scolopidium. Because of their position, it is not probable that these scolopidia belong to the other scolopophorous organ found in the pedicel of most Neoptera, the central organ, which is characterized by mononematic scolopidia. So, the central organ is probably only represented by the remaining isolated mononematic scolopidium.

## **S1.5.** SPERM MORPHOLOGY AND INSECT SYSTEMATICS **1**

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Previous researches carried out on Insect sperm structure have demonstrated the great importance of this cell for the phylogenetical evaluations of this class. After this demonstration several researches have been carried out on related genera and species, in order to investigate a possible utilization of the spermatozoon in the problems of the minute systematics. Data available in literature concerning Protura, Coccidae, Isoptera, Diptera are quite convincing. Moreover unpublished data on the whole group Orthopteroidea, on the Rhynchotan family Psyllidae and on the order Coleoptera show many new important diagnostic characters. These concern presence or absence of flagellum and acrosome, more delicate structural characteristics of the accessory bodies, axoneme, mitochondrial derivatives and, in closely related species, also the shape of the head and the total length of the sperm.

## **S1.5.** TYPES OF CELLS ASSOCIATED WITH THE MALE AND FEMALE **2** SEXUAL CELLS AT INSECTS.

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We have studied, at some species of insects, in optic and electronic microscopy, the structure of the ovary and of the testis, in normal and experimental conditions.

In addition to the sexual cells of the insects, we have described in the ovary the nutritive and follicular cells. We have shown the changes undergone by the follicular epithelium in different conditions, especially its role as a selective barrier in the transit of substances between the haemolymph and the oocyte. In the testis, we have shown, the very close relationships between the conjunctive and the sexual cells, the support, trophic and phagocytic roles of the conjunctive cells and the possibility of steroid biosynthesis, due to some ultrastructural characteristics and histochemical reactions.

## S1.5. PAIRED SPERMATOZOA IN THERMOBIA (THYSANURA)

3

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Thermobia spermatozoa after a conventional spermiogenesis pair to form twin spermatozoa. This feature seems to be essential for sperm movement: free cells have a reduced motility or are immotile. The pairing is evident only in the anterior third of the spermatozoa which contains nucleus, axoneme and two mitochondrial derivatives as four parallel, longitudinal strands. The contact of the two spermatozoa is realized by the close proximity of the two plasma membranes which here form a kind of close junction. Freeze fracture replicas reveal at this level particle rows, one row on each spermatozoon; the rows of the two spermatozoa in a pair meet along the junction. In addition double rows of particles are evident on the mitochondrial derivatives presumably connecting these structures to the axoneme.

## S1.5. COMPARATIVE SEM ANALYSIS OF THE EGG IN THE BACILLUS GENUS (PHASMATODEA BACILLIDAE)

4

MAZZINI M.<sup>1</sup>, NASCETTI G.<sup>2</sup>, SCALI V.<sup>3</sup> and BULLINI L.<sup>2</sup>

1 Institute of Zoology, University of Siena, Italy 2 Institute of Genetics, University of Rome 3 Institute of Zoology, Bologna, Italy. Ootaxonomy based on the egg chorion sculpturing at the SEM level, has been widely and successfully used in many Insect Orders. In the Phasmatodea (Cheleutoptera) also, such a study has given useful information. Particularly for related species and even for intraspecific taxa of the Bacillini the chorionic sculpturing appears of important diagnostic value. In this way a number of species have been characterized: the bisexual B. rossius and B. grandii and the parthenogenetic species of hybrid origin: B. whitei (from the cross between B. rossius x B. grandii), B. linceorum (B. whitei x B. grandii) and B. atticus (B. grandii x missing ancestor). The chorionic patterns of all the reported species, is at the same time distinct and clearly related. Within B. rossius, whose analysis has been more extensively carried out, a variety of geographic subspecies have been characterized: B. r. rossius, B. r. redtenbacheri, B. r. montalenti, B. r. lobipes, B. r. tripolitanus. The number of infraspecific taxa is bound to increase further. The ootaxonomic results are in full agreement with electrophoretic data on gene-enzyme systems and also with karyological data.

## S1.5. Comparative analysis of ovarian development in DROSOPHILA and BACILLUS

5

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Vitellogenesis plays a key role in ovarian development. Crucial steps in the control of vitellogenesis in insects are: 1) synthesis of vitellogenin in the fat body and 2) endocytic transfer of vitellogenin in the oocyte. Both of these processes are known to be hormonally controlled.

In this context we ask the question how is the oocyte caused to undergo endocytosis. To answer this question experimentally we have examined the follicle cell-oocyte interaction in both Drosophila and Bacillus by a variety of observations. Our observations show that at the time of vitellogenesis inception, the follicle cell-oocyte interface is characterized by: 1) extensive interdigitations through microvilli; 2) gap junctional contacts and 3) interaction through follicle cell microvilli.

Based on this evidence we suggest that the follicle cell epithelium in insect ovarian follicles regulates uptake of vitellogenin. Our model thus predicts that the hormonal dependence of vitellogenesis in insects is exerted over the oocyte via interaction with the overlying follicle cell epithelium.

## S1.5. CONTRIBUTIONS TO THE COMPARATIVE SPERMATOLOGY OF THYSANOPTERA

6

BODE, W.

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During the last years, the traditional division of the Thysanoptera into a suborder "Terebrantia" and a suborder "Tubulifera" has been largely refused, and the "Terebrantia" have been considered as a paraphyletic group. But now, the study of sperm ultrastructure in representatives of two "terebrantian" families, the Thripidae and Aeolothripidae, has shown evident synapomorphies: There is no distinct acrosome. Nucleus and mitochondrial derivative are rodlike; in the middle of the cell, they run parallel. The configuration of the 18 doublet and 9 singlet tubules is different from all patterns known so far. The structure of the singlets corresponds to that of subfiber A of the doublets. This flagellar tubule pattern is formed by penetration and alteration of three "9+0" flagella during spermiogenesis. - On the other hand, the sperm structure of the "tubuliferan" (=phlaeothripid) species *Cryptothrips nigripes* is characterized by the presence of an acrosome and an "18+4" flagellar tubule pattern (BACCETTI et al., 1969). This reminds of the tendency to "biflagellarity" known from other Acercaria and must be considered as plesiomorph. After all, the analysis of sperm morphology in comparison with other criteria suggests monophyly of the Terebrantia.



## 51.5. TRICHOPTERA AND LEPIDOPTERA BRANCHING BY COMPARATIVE SPERMATOLOGY

7

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Close phylogenetic affinity between Trichoptera and Lepidoptera is supported by morphological embryological and cytological data. But the divergence of the orders and that of different systematic groups within them is still disputed. Our comparative spermatological studies showed: Two types of spermatozoa, nucleate and anucleate, occur in normal Lepidoptera, including the very "primitive" families Micropterigidae and Hepialidae. Only nucleated spermatozoa are present in Trichoptera, each species displaying only one kind of spermatozoon. These data indicate that Lepidoptera branched from the common ancestor after Trichoptera, as only one spermatozoon type characterizes most of the systematic groups of animals, including Mecoptera which appear to be closely related to, and more primitive than, both Trichoptera and Lepidoptera. The two suborders of Trichoptera differ in that Integripalpia display regular spermatozoa as found in most insects, while Annulipalpia display aberrant types of spermatozoa.

## 51.5. CECIDOMYIID SPERMATOZOA AND SYSTEMATICS

8

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Sperm morphology often reveals the phylogenetic relationship between different higher taxa or between genera within the same family. This is true also of Cecidomyiids. The subfamily Porricondylinae thus can be recognized as a primitive group within the family; it is the only one to have retained spermatozoa of the conventional dipteran type. Other gall-midges can be divided into two main types, which presumably represent different evolutionary lines. In the one line, represented by Asphondylia, Mycodiplosis, Syndiplosis, Braueriella, Aphidoletes, Cecidomyia, Monarthropalpus, Kiefferia, Diplolaboncus, these are motile spermatozoa of a particular type. In the other line, represented by Contarinia, Lestodiplosis, Myricomyia, Gephyraulus, Prolasioptera, Lasioptera, Dasineura, Mayetiola, Oligotrophus, Dryomyia, Diarthronomyia, Jaapiella, Rabdophaga, Cystiphora, Wachtliella, Macrolabis, Semudobia, the spermatozoa are immotile and highly aberrant. Species within a single genus (Contarinia and Dasineura) also can be recognized by their different morphologies. It seems evident that sperm ultrastructure is a useful and valid indicator of systematics in gall-midge as well as many other taxa.

S1.5.  
10

## THE SPERMATOGENESIS IN HAPLOID MALES OF HYMENOPTERA

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The thorough descriptive studies by early cytologists provided a remarkably accurate picture on the microscopic anatomy of hymenopteran spermatozoa and spermiogenesis in several species. Their light microscope observations were, however, necessarily lacking in detail. Otherwise only few studies were undertaken on the subject since the advent of the electron microscope. The studies made so far raised some questions about the behavior of chromosomes and centrioles during meiosis and about the spermatids differentiation.

In several species of bees already studied the first meiotic division ends in an anomalous metaphase with concentric layers of endoplasmic reticulum encircling the chromosomes and although the centrioles proliferate during prophase I, they did not produce a spindle but are eliminated from the cell. The second meiotic division originates two spermatids with different amounts of cytoplasm the small one with practically no cytoplasmic organelles. Nevertheless, some evidences indicate that both cells produce spermatozoa.

The present report discusses the available knowledge about the above questions and the spermatozoa structure in bees, ants and wasps.

S1.6.  
2

## COPHYLOGENY OF ANOPLURA AND PRIMATES

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The twenty-six species of Anoplura infesting seven families of Primates (excluding Tupaiidae) belong to six genera. Three of these genera are monotypic, the three others (infesting Prosimian Primates) belong to the same family. As these four Anopluran families are not mutually related there is obviously no cophylogeny on the family level of hosts and parasites. Rather close cophylogeny, however, is established between Primate families and Anopluran genera and species. On the basis of Anopluran genera, species, and subspecies examples are presented demonstrating positive as well as negative cases of cophylogeny. These cases are discussed by considering phylogenetic, historical, geographic and/or ecological arguments.

**S1.6.** PHYLOGENETIC RELATIONSHIPS BETWEEN POLYPLACIDAE (ANOPLURA) AND  
**3** MAMMALS

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The Polyplacidae are the largest family-taxon in Anoplura and primarily associated with the Rodentia. Some taxa have expanded their associations to the Lagomorpha, Insectivora, and even Prosimian Primates. Taxonomic relationships of polyplacid taxa and their hosts will be assessed and their cophylogeny inferred.

**S1.6.** COPHYLOGENETIC EVIDENCE FROM LICE OF ABERRANT RODENTS  
**4**

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Two species of sucking lice were collected off Typhlomys cinereus from Guizhou, China. Mirophthirus liae is heavily chitinized. It has a broad head and thorax, with the legs long and slender and widely set apart. The middle pair of legs is the longest with a span equalling body length. The thorax with only the middle portion of pro- and meso-nota, and the pro- and meso-sternites fused. The sutures of the thoracic segments are obvious. We made a new family for it, the Mirophthiridae.

The other louse, Typhlomyophthirus bifoliatus was placed under the family Haematopinoididae, characterized by having longitudinally splitted 2nd sternite of the abdomen. Hence the family contains four genera: Haematopinoides and Ancistroplax off Talpidae and Soricidae of Insectivora, and Schizophthirus and Typhlomyophthirus off Gliridae and Platacanthomyidae of Rodentia. Infestations of all the four genera of lice on their respective hosts are considered to be primary.

The monotypic genera Typhlomys and Platacanthomys form the family Platacanthomyidae which had been a sub-family of Muscardinidae of Gliridae. Platacanthomys is Indian and Typhlomys is Oriental. The Typhlomyophthirus and Mirophthirus are the only sucking lice recorded from rodents of this family.

## S1.6. EVOLUTION OF TRICHODECTIDAE (PHTHIRAPTERA: ISCHNOCERA) AND MAMMALS

6

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A cladogram of the species of Trichodectidae is compared with the phylogenies of their mammalian hosts, the most extensive comparison of this type for any parasite group. The comparison reveals mismatches requiring the postulation of 41 secondary infestations and associated speciation events. This is 20.7% of all speciation events in the history of the Trichodectidae (Geomydoecus excluded), a proportion much higher than expected. This necessitates the rejection of Fahrenholz' Rule in all but the most general sense.

P1.-  
1

## EPIDEMIOLOGICAL STUDIES ON TICKS IN NIGERIA; THE ECONOMIC IMPLICATIONS AND CONTROL METHODS

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Studies have shown that there is an abundance of various species of ticks in Nigeria. This abundance is favoured by the tropical climatic conditions of the country. The commonest tick species are *Amblyomma variegatum*; *Boophilus decoloratus*; *Boophilus geigyi*; *Hyalomma rufipes*; *Rhipicephalus sanguineus* and *Haemaphysalis leachi leachi*.

These ticks and others cause enormous damage to hides and skin due to injuries of tick bites. They also suck blood and transmit a vast number of diseases to man and his domestic animals. The economic implications and control methods are discussed.

**P1.-** MAINTENANCE OF HIPPOBOSCA EQUINA L. (DIPTERA:HIPPOBOSCIDAE)  
**2** FED THROUGH PARAFILM MEMBRANE ON DEFIBRINATED BLOOD.

M. FOUDA

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Nasr-City, Cairo, Egypt.

Hippobasca equina flies were successfully reared in the absence of living host animals using a technique developed in the laboratory. The flies were fed through parafilm membrane on defibrinated bovine blood. Using this technique nearly 100% of the flies engorged blood through the membrane. The reproductive performance of H. equina fed through the membrane in terms of female survival, fecundity and pupal weight were almost the same as that of flies reared on guinea pigs. More than 70% of the females fed through the membrane survived for 40 days. The mean number of puparia laid by the initial female was 6.2. The mean weight of the puparia laid by these flies was 18.0mg. The results obtained develop a useful technique which would eliminate many problems accompanied with the rearing of H. equina on living host animals.

**P1.-** A REVISION OF THE THORECTES SPECIES OF THE GROUP ESCORIALENSIS IN THE  
**3** IBERIAN PENINSULA ( COL. SCARABAEOIDEA, GEOTRUPIDAE )

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SPAIN

A review has been done of the Thorectes species of the group escorialensis. After a study of 458 specimens it has been concluded that only there are two species: Thorectes escorialensis (Jekel, 1865) and Thorectes punctatissimus (Chevrolat, 1840). Th. petrovitzi Baraud, 1970 is a synonymy of Th. escorialensis (Jekel, 1865).

Thus, it has been deduced from this study that Th. escorialensis has a distribution in the mountains of the Sistema Central and the proximate areas of the west coast of the northern third of the Iberian Peninsula. In the region of Galicia is more abundant in the coast areas than in the interior.

On the other hand Th. punctatissimus is present in the mountains of the interior of Galicia.

P1.-  
4 STUDIES ON APHID TRANSMISSION OF PAPAYA RINGSPOT VIRUS

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Experiments conducted in the net house showed that the papaya ringspot virus (PRSV) could be transmitted by mechanical means, infected plant in contact with healthy plant, or by the green peach aphid, Myzus persicae Sulzer, corn leaf aphid, Rhopalosiphum maidis Fitch, etc. The green peach aphid was found to be able to transmit PRSV in the laboratory for 6 hours after acquisition feeding. The infected papaya whereas demonstrated its infectivity in 2 weeks after inoculation. The application of oils or milks in the papaya orchard showed no protective effects. The placement of reflective white plastic cloth on the ground could not avoid the landing of alate aphid, so it would be of no practical value for papaya protection.

P1.-  
5 FAUNAL COMPOSITION AND DISTRIBUTIONAL PATTERN OF PSYCHODIDAE FROM INDIA

IPE, I.M., IPE, AGNES and RAM KISHORE, School of Entomology, St. John's College, AGRA-282002, INDIA.

Genus Psychoda has emerged as the dominant genus in the region after the present investigations forming 36.14% of the non-phlebotomine psychodids studied followed by Pericoma with 21.68% and Telmatoscopus with 14.45 % and Brunettia with 12.04% representation. The remaining genera has got only marginal representation with Horiekla, Philosepedon and Peripsychoda with 2.40% each and Clogmia, Mormia, Neotelmatoscopus and Panimerus with 1.20 % each. None of the genera are exclusive to the region. However, 59 species belonging to 12 genera studied are endemic to India whereas five species each are endemic to Sri Lanka and Nepal respectively. 14 species are widely distributed in India Sri Lanka and Nepal. It is possible in the light of the studies of the distributional pattern of the 83 species to recognise a few genera as cold loving and limited only to higher elevations in the region while a few others represented only in the plains not extending to the colder higher elevations of the North.

P1.- PHYLOGENETIC RELATIONSHIPS WITHIN THE SUBFAMILY  
6 TELENOMINAE (HYMENOPTERA: SCELIONIDAE)

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The 600+ described species of the Telenominae are grouped into 12 genera. Most are placed into 2 large paraphyletic genera: Telenomus and Trissolcus. Trissolcus is made up of at least 3 species groups: the flavipes group, the thyantae group and the basalis group. A sister-group relationship is proposed between Nirupama and Archiphanurus; together these are most closely related to Psix. These 3 genera share a plesiomorphic feature, striate frons, with some species of the Trissolcus thyantae group, suggesting they may be relatively primitive telenomines. Phanuropsis is derived from the Trissolcus flavipes group; the latter is also closely related to the Telenomus podisi group. The genus Telenomus consists of at least 12 groups. Issidotelenomus has been proposed for the Telenomus crassiclava group. Eumicrosoma and many species classified as Platytelenomus are derived from the Telenomus floridanus group. The type species of Platytelenomus probably belongs to the Telenomus californicus complex of species. The position of the monotypic genera Phanuromyia, Aradoctonus and Phlebiaporus is uncertain. Progress in our understanding of the phylogenetic relationships within the subfamily is a necessary first step toward a reclassification consistent with the criterion of monophyly.

P1.- SOME PHYLOGENETICAL ASPECTS OF STENANTHY AND EURYANTHY IN BEES  
7 (HYMENOPTERA, APOIDEA)

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It is argued that the euryanthic behavior of Hymenoptera Apoidea is a highly developed feature representing the precondition ("preadaptive plateau") of longer time of flower-visiting during the year, of bivoltinism and socioevolution. Stenanthy can be interpreted as an original feature and, in middle European bees, can only be understood with regard to the history of flora and fauna of the postglacial period.

P1.-  
8 TO THE CLASSIFICATION OF GENUS PTEROCHEILUS KLUG ( HYME-  
NOPTERA, EUMENIDAE ) FROM PALEARCTIC REGION

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From the genus *Pterocheilus* Klug ( type species - *P.phalera-*  
*tus* ) the genus *Onychopterocheilus* Blüthg. ( type species -  
*P.daw* ) is singled out. The latter taken in a wider sense in  
comparison with Blüthgen ( 1955 ). Both of the genera are di-  
vided into several subgenera and species-groups.

*Odontopterochilus* Kost. is a paraphyletic group. *P.heptneri*  
is included into *Pterocheilus* s.str., the rest of the species  
( *P.turovi*, *P.uralensis*, *P.dementievi*, *P.skorikovi* ) - to the  
two subgenera of *Onychopterocheilus*.

P1.-  
9 BIOCHEMICAL TAXONOMY AND SYSTEMATIC REVIEW OF THE GENUS CALOPTERYX  
LEACH (ZYGOPTERA, ODONATA) IN EUROPE.

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A systematic review of Westeuropean species of *Calopteryx*, based on new  
morphological and biochemical data, is presented. Vertical electrophoresis  
on starch gel offers a new possibility of research in the taxonomy of  
Odonata. It allows the establishment of the taxonomical level of each species  
and subspecies. Identity ( $\bar{I}$ ) and genetic distance ( $\bar{D}$ ) matrix is given, as  
well as a dendrogram showing the different levels of speciation related to  
these forms. In the view of these results, a new approach of this group is  
discussed.



**P1.-** AN ATTEMPT TO RECOGNIZE SOME PHYLOGENETIC RELATIONSHIPS  
**10** AMONG SOME NEOTROPICAL TENEBRIONID BEETLES

GIORGIO MARCUZZI

Depnt of Biology, The University, Padova, Via Loredan 10

The ovipositor shows a greater interest than the aedeagus, at least in some tribus and genus. Some problems such as the origin of Epitragini genus Stictoderia and Tapinocomus and still more the effect of geographical isolation in the genus Distolinus are resolved, also on zoogeographical grounds. Trichotoides, Austrocaribius and Hummelinckia, separated since long time from the original stock, show very evident divergences in aedeagal structures. Also within Blapstinus, Opatrinus and Trichoton some possible trends in speciation are demonstrated. The ovipositor, which had never been studied in the species here illustrated, shows primitive characters in Rhypasma, evolved in Epitragini and in the three very isolated tribus, limited to the southernmost part of South America, Nycteliini, Praocini and Scotobiini. Opatrini and Pedinini, present also in the Old World, are not very different on the ground of ovipositor structure. The oldest tribus characteristic of humid tropical forests exhibit a rather similar ovipositor. Ulomini though belonging to this group of tribus, are quite different when ovipositor is considered.

**P1.-** RELATIONS AND PECULIARITIES OF THE GEOGRAPHIC DISTRIBUTION  
**11** OF THE TENEBRIONID TRIBE HYOCINI (COLEOPTERA, TENEBRIONIDAE)

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199034, LENINGRAD, ZOOLOGICAL INST. ACADEMY OF SCIENCES, USSR.

The tribe Hyocini G. Medvedev et Lawrence was described not long ago from Australia. The mesocoxal cavities in all Hyocini are closed laterally by meeting of the meso- and metasterna. This feature is characteristic of many groups of the tentyroid lineage of Tenebrionidae. In other characters the darkling beetles of the tribe Hyocini are typical members of the tenebrionid lineage of Tenebrionidae. They have well-developed abdominal defensive glands, the dorsally oriented tegmen, multipronged antennal sensillae. The set of imaginal characters (structure of the female genital tube, antennae, details of wing venation) as well as the larval ones (structure of the fore legs and IX abdominal segment) suggest the placement of Hyocini to the diaperoid lineage, consisting of the Diaperini, Nilionini, Hypophloeini and Phalerini. The areal of the tribe Hyocini covers large part of Australia.

P1.-  
12 YPONOMEUTID FAUNA OF THAILAND (LEPIDOPTERA, YPONOMEUTIDAE)

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The study of zoogeography of Southeast Asia in respect of the Lepidoptera is not well advanced. In this region, the present knowledge of the fauna of moths of Thailand is still in a fragmentary state, and that of the Microlepidoptera is especially in an infantile stage. During my 1981 and 1983 Thai Expeditions, 35 Yponomeutid species, representing 17 genera, were collected. The available material of Yponomeutidae, however scanty, has a pronounced Oriental character, with marked elements from India, Sri Lanka and Borneo. Most of the genera are widely distributed in the Oriental Region. The Palaearctic element is not numerous, but the fauna has some genera (e.g., Thecobathra, Parahypopnomeutoides and Kessleria) in common with Thai one. Endemism at the generic level is not striking; Angoonopteryx is an only interesting endemic genus at present.

P1.-  
13 KARYOTYPIC EVOLUTION IN SAWFLIES (HYMENOPTERA, TENTHREDINIDAE)

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The chromosomes of about 200 sawfly species of the family Tenthredinidae were examined with embryos induced by an artificial parthenogenesis. My haploid embryo technique has the advantage of getting high quality metaphase figures and of studying many more sawfly species cytologically because adult females collected in the field are available for chromosome preparation.

The haploid chromosome numbers of this family ranged between 5 and 22, and about three-fourths of the species showed  $n=7-10$ . The distribution range of haploid number at subfamily level was  $n=5-14$  (7) in the Selandriinae,  $n=6-9$  (8) in the Nematinae,  $n=6-16$  (8) in the Allantinae, and  $n=8-22$  (10) in the Tenthredininae, where the modal numbers are in parentheses. Based on the correlation between chromosome number differentiation and morphological evolution, it was implied that the karyotypic evolution in the Tenthredinidae has been proceeding, as a whole, toward increasing their chromosome number.

P1.-  
14

CONTRIBUTION TO THE KNOWLEDGE OF CUCUJOIDEA (COL.) OF SPAIN  
I.- THE GEN. CRYPTOPHAGUS (HERBST.)

J.C.OTERO

DEPTO ZOOLOGIA-FAC.BIOLOGIA-SANTIAGO COMPOSTELA- SPAIN

A list of Cryptophagus (Col. Cryptophagidae) captured in Spain, with morphological data, detailed geographic distributions of studied specimens is given.

The Catalogue of Fuente y Morales (1927: 114-120) is brought up date in nomenclature and certain species recorded therein are indicated as requiring confirmation as members of the Iberian fauna.

P1.-  
15

CONTRIBUTION TO THE KNOWLEDGE OF GENUS OPIUS WESM. IN SPAIN  
(HYM., BRACONIDAE, OPIINAE)

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The fauna of the Opiinae has a very wide distribution in different habitats and it has been studied by various research workers in -- most parts of the World, but the Spanish fauna has not been investigated previously.

In this survey, we enlarge on the knowledge presently available on the distribution of the genus Opius in Spain, pointing out the -- different species found and some aspects about its biology.

The material was mainly collected in different localities of -- the East of Spain.

P1.-  
16

## VENATION AND TRACHEATION OF WINGS IN SATURNIID MOTHS

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The changes of tracheation from the pupal to the imaginal wings are investigated. Most observations are derived from the adult development of *Philosamia cynthia*, *Antheraea yamamai*, *Saturnia pyri* and *Eudia pavonia*. In all these species the number of wing veins is reduced by the superimposing of the first median branch on the last radial branch; this combination seems to be unique in Lepidoptera. Additional reductions occur in the first and second radial branch. The results of this study lead to a modified notation of veins for Saturniidae which is compared with other systems.

P1.-  
17

## TAXONOMIC STUDIES BASED ON PHLEBOTOMINE SANDFLIES IN KENYA

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ABSTRACT - The females of Phlebotomus martini Parrot (the vector of visceral leishmaniasis in Kenya) is morphologically similar to the females of other members of the Synphlebotomus complex of Kenya namely P. vansomeranae Heisch, Guggisberg and Teesdale and P. Celiae Minter.

Similarly the females of P. pedifer Lewis, Ashton and Mutinga are morphologically indistinguishable from the females of P. elgonensis, Ngoka, Madel and Mutinga. Identity is only possible by use of the male terminalia. Isoenzyme identification methods and the Scanning Electron Microscope was used to try and separate these closely related females.

P1.-  
18

INTEGRATED TAXONOMY ON DERMAPTERA 1  
NUMERICAL TAXONOMIC INFORMATION ON MALE GENITALIA.

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All known species are 4 suborders, 11 families in 4 superfamilies, 53 subfamilies, 203 genera, 1846 species including 38 fossil species, 40 varieties, 37 subspp. and 7 forms at 1983. PCA and 6 cluster analyses of male genitalia of Anisolabis maritima by FACOM M140-6 computer demonstrated small values of fluctuating variation of genitalia than the other morphological characters. 54 genital score distribution at 35 localities of all Japan showed remarkably aggregation of 3 dimensional space like a cloud but external characters-score is scattered in space on the contrary. There is no tendency of biogeographical cline. Similar multivariate analyses of Labidura riparia japonica indicated similar tendency. JSMT-20 Scanning electron microscopic photographs of several families on male genitalia were observed for phylogenetic reconstruction. The tip of the penis lobe was observed to be covered by the so many interesting spines. The chitinous spines of the distal paramere were compared and presented the species specificity. The photographs were recorded by scanning photo pattern analyzer and measured by Omnicon image analyzer involving Nova computer. Several variables of image analyses on genitalia were used for phylogenetic reconstruction as well as many slides-microscopic photographs of several museums of America and Europe. A new proposed classification is presented. The results of the proposed classification seem to revise to more better acceptable system with joint of the other integrated taxonomy as chemotaxonomy, cytotaxonomy and physicotaxonomy in future. Ref. SAKAI, S. (1970-1983): *Dermapterorum Catalogus Praeliminaris* I to XV.

P1.-  
19

STRUCTURE AND FUNCTION OF THE BEE ANTENNA CLEANER,  
AND ITS USE FOR TAXONOMY (HYMENOPTERA, APOIDEA)

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Like other Hymenoptera bees have a tibio-tarsal antenna cleaner (AC) on their fore legs. The morphology of the AC was studied throughout all major groups of Apoidea (MICENER, 1974) using light- and scanning electron microscopy. Furthermore living bees of 25 genera were studied.

There is a common type of AC amongst the Colletidae, Andrenidae, Halictidae, and Melittidae, which is considered to be ancestral. In the other families different types of AC have evolved. Within the Anthophoridae some genera (Anthophora, Eucera, Xylocopa, and others) have a derived AC, while others have an ancestral one (Nomada, Ceratina). This coincides well with the new systematic approach by WARNCKE (1977).

Many bees clean their antenna scraping it generally only once at a time (Apidae, Megachilidae, Xylocopa, Eucera, Anthophora, Melitta, Macropis, part of Andrena), whereas others clean it usually with two subsequent strokes of the same leg (Colletidae, Halictidae, Nomada, part of Andrena). Multiple antenna cleaning is considered to be ancestral, and it is generally, but not always correlated with an ancestral morphology of the AC.

P1.-  
20

## A KARYOTYPICAL APPROACH TO CARABOID EVOLUTION

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It is assumed that the karyotype with  $2n(\sigma) = 36+X$  is the most primitive of Caraboidea and its sister group Dytiscoidea, as it is the only number repeated in several phylogenetic lines.

Karyotypic studies of about 500 species suggest a close relationship between changes in this primitive karyotype and degrees of morphological and ecological evolution, so that high rates of karyotypic evolution usually lead to lineages with lower potentiality, morphological conservativeness and ecological specialisation, whereas moderately to low rates suppose an "undifferentiated condition" which gives higher potentiality to other lineages.

Several comparisons among tribes are made to test this hypothesis: 1) Cindellini and Carabini are thought to be primitive lineages because of their early high rates towards low-numbered karyotypes and lower DNA content; 2) Pterostichini and Harpalini represent modern and successful groups in which most of their supraspecific taxa keep the  $2n = 37$  karyotype, thus making possible a great diversification of evolutionary patterns at several levels of phenotypic integration. Taxa of these or related tribes diverging markedly from the  $2n = 37$  condition (i.e., Zabryini) show again specialisation in relation to their close relatives not so far evolved.

Patterns of karyotypic evolution are also useful when discussing phylogenetic relationships; two examples (Lebiini and Brachinini stocks) are given.

P1.-  
21

## PAINTINGS OF PTEROMALIDAE (HYMENOPTERA)

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ST IGNATIUS COLLEGE, P O BOX 1780, HARARE, ZIMBABWE

Chalcids have been collected near Harare, Zimbabwe since 1967. These have been determined to genera and in many cases to species level by Dr Z Bouček, CIE, BM (NatHist). It was decided that it would help workers in ecology etc if these were illustrated. The first chalcid family to be illustrated is Pteromalidae of which some 75 genera have been collected.

**P1.-** THE SURFACE STRUCTURE OF THE FIRST INSTAR LARVA OF *Oestrus*  
**22** *ovis* L. AS SEEN WITH THE SCANNING ELECTRON MICROSCOPE

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Taiyuan, Shanxi, China

**Abstract:** The fine surface structures of the first instar larva of *Oestrus ovis* L. was described and illustrated with the aid of a scanning electron microscope. The scanning electron micrographs seem to have a taxonomic value and are useful in clinical precise identification of myiasis caused by Oestrid larvae.

Section 2 Morphology and Functional Morphology .....

R 2.1. *Morphology* .....

R 2.2. *Locomotion* .....

R 2.3. *Functional Morphology and Food or Host Relationships* .....

R 2.4. *Cuticle Surface Structure and Function* .....

S 2.1. *Insect Brain: Its Evolution, Development, Structure, and Function* .....

S 2.2. *Functional Morphology of Insect Sensilla* .....

S 2.3. *Functional Morphology in Insect Vision* .....

P 2. ....

F 2. ....



## R2.1. GENERAL TRENDS OF EVOLUTION COMMON BOTH TO INSECTS 1 AND HIGHER VERTEBRATES

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Representatives of higher insects and higher vertebrates, after the transition to terrestrial life have conquered the air environment adjusting themselves to the deficiency of moisture in the atmosphere. Similar adaptations developed both in Amniota-Sauropsida and in Insecta-Pterygota. These adaptations are as follows: relatively impermeable tegument (instead of the permeable one of water and soil dwellers); uricotely instead of ammonotely and ureotely of lower aquatic groups; opening of excretory ducts into the hind gut instead of outside in aquatic forms; respiratory cavities instead of gills or skin respiration; internal insemination developed from the external one through the externat-internal spermatophore insemination; cleidoic eggs instead of uncleidoic ones of aquatic and lower soil dwelling groups; formation of amniotic cavity absent in aquatic and primitive groups in which eggs develop in the moist soil. Parallelisms in adaptations solving in similar ways physiological problems on the basis of non-homologous structures in different phyla due to a new environment allow to comprehend the general trends of their evolution.

## R2.1. APPARENT SYNAPOMORPHIES IN THORACIC MORPHOLOGY OF MICROPHORUS 2 AND DOLICHOPODIDAE (DIPTERA, EMPIDOIDEA)

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In the thoracic skeleto-muscular system of Microphorus holosericeus (Meigen) three apomorphic characters apparently independent from each other are shared by Dolichopodidae but none of the other Empidoidea studied earlier: a, in the anterior ventral neck membrane, an unpaired transverse sclerite is developed; b, each ventral metapleural arm is produced meso-dorsad to form a rodlike structure to which a bundle segregated from the pleural levator muscle of hind trochanter is attached; c, postmetanotum bears a pair of apodemes apparently homologous to the metanotal apodemes of Dolichopodidae although much smaller and partly differing in their relations to musculature. These findings seem to support the hypothesis raised by Colless, 1963 and corroborated by Hennig, 1971 that Microphoridae are more closely related to Dolichopodidae than Empididae, Hybotidae, and Atelestidae (all sensu Chvála, 1983).

**R2.1.** The unusual structures of metasoma's morphology  
**3** of Ceraphronoidea (HYMENOPTERA)

ZOOLOGICAL MUSEUM OF MOSCOW  
 ALEKSEEV VLADIMIR N. UNIVERS., MOSCOW, USSR

Ceraphronoidea have unusual structures of the base of the metasoma. The 1-st metasoma's segment greatly reduced and turn into joint tube. The fore-part of metasoma seems to be formed only by the 2-nd tergite. However, the neck metasoma's structure of some species shows, that it formed and by 2-nd sternite too. The 2-nd sternite nearly combined with the 2-nd tergite.

The males genitales of Ceraphronoidea are characterised by the massive basic ring, jointed basiparameres, mobilizing parameres and very large digites.

**R2.1.** SOME MORPHOLOGICAL FEATURES OF SPIRACULAR SYSTEM IN  
**4** SELECTED COLEOPTERAN INSECTS

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The morphological variations of the spiracular system in different taxa of coleoptera reflect their ecophysiological importance. The comparative morphometric studies revealed differences in size, filter device and development of the atrium in the spiracles. The general trend is towards a reduction in the size of the posterior spiracles with the corresponding decrease in their components. The total apertural area was found to be maximum per unit weight in aerial beetles compared to the terrestrial and aquatic ones. The metathoracic spiracles lack filter apparatus and atria whereas the mesothoracic and abdominal spiracles are with dense filter apparatus and are with atria of variable depths. The enlarged metathoracic spiracles in large aerial beetles are designed to circulate air through thorax, a region of intense metabolic heat. The mesothoracic and abdominal spiracles are covered by obstructions having crucial role in prohibiting heat dissipation which is a welcome phenomenon. Concomitant studies of respiratory metabolism and temperature regulation have been carried out to correlate the anatomical parameters with their function.

**R2.2.**  
**1** INSECT LOCOMOTION: STRUCTURE AND FUNCTION IN COLEOPTERA, PARTICULARLY  
CARABIDAE

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Zoology Department, Manchester University, Manchester M13 9PL, U.K.

Some beetles have obvious locomotor specialisations; e.g. fast running/weak pushing tiger beetles and slow running/strong pushing dung beetles have contrary skeleto-muscular adaptations of the legs and leg muscles. However, these converse locomotor abilities are merely the extremes of a wide range of speed/force compromises. This was shown by measuring the maximum pulling (= pushing) forces and sprint speeds of many beetles. When the reciprocal parameters of relative speed and relative force were graphed, the species distribution showed both the variety of speed/force compromises, and their relative locomotor "efficiencies". Carabidae are highly efficient locomotor specialists, which include rapid sprinters, medium speed/force species, and powerful burrowers. These groups reflect different habits of life rather than particular habitat adaptations, and in evolutionary terms they are probably polyphyletic.

**R2.2.**  
**2** THE SUPPLY OF THE FLIGHT MOTOR OF M E L O L O N T H A AND  
OTHER BEETLES WITH AIR AND FAT.

P. SCHNEIDER, B. HOESE and H.H. JANSEN

Im Neuenheimer Feld 504, D-6900 Heidelberg 1

The construction of trachea, tracheoles and the penetration into the muscle fibers is compared with the flight metabolism. The tracheoblast, which surrounds the tracheoles, consists of many small cells, which are filled with fat vesicles. The cells of the tracheoblast accompany the tracheoles in the muscle cells and end near by the mitochondria. In relation to development, age, basic metabolism, flight performance and flight type this tracheoblast is presented and discussed.

15 min.

**R2.2.**  
**3** OBSERVATION OF THE CLAWS ON THE ABDOMINAL LEGS OF CERTAIN SATURNIID LARVAE.

OKUI, KAZUMITSU

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Most lepidopterous caterpillar have a certain claws on the planta as the end of their abdominal legs. According to Tanaka(1928), it's considered that these claws related to moving activity of caterpillar. Most claws are usually arranged limited to a semicircle or small arc on the inner margin of the planta. In such case, the planta itself generally became asymmetrical by a reduction or obliteration of it outer half(Snodgrass,1935). The form of claws and their arrangement differs by species, and number of claws changes in each instar. Then the author supposed that compared with the claws of closed species may be indicated to a process of species differentiation. And perhaps, will be considered the relation with their behavior, for example, the case of climbing activity.

In this report, the author carried out observation by scanning electron microscope from 1st to 3rd instar larvae of certain Saturniid insects and had been compared its.

**R2.3.**  
**1** SENSILLAR AND FUNCTIONAL ANATOMY OF BITING MIDGE (DIPTERA: CERATOPOGONIDAE) MOUTHPARTS

JAMES F. SUTCLIFFE & PAUL DEEPAN

Dept. of Biology, University of Waterloo, Waterloo, Ontario, CANADA, N2L 3G1

Sensillar complement of the mouthparts of a biting midge (Culicoides sp.) is described using light, scanning electron, and transmission electron microscopy. This information is integrated with results of similar studies of mouthpart morphology, yielding an interpretation of stylet function during biting in this insect. Comparisons of this process are made with biting dynamics in simuliids and culicids.

**R2.3.** FUNCTIONAL MORPHOLOGY OF THE MOUTHPARTS OF AEDES VEXANS MEIG - LARVAE  
**2** (DIPTERA: CULICIDAE)

CHRISTOPH ALY

University of California, Riverside, California, 92521

The mouthparts of Aedes vexans were examined at each larval instar with the aid of light- and scanning electron microscopy. The larvae of all 4 instars are particle feeders. The hairs of the labral brushes, which are serrated over their whole length act as a primary filter, collecting particles during the movements of the labrum. The mandibles perform 4 functions during adduction: (1) combing particles out of the labral brushes, (2) reducing larger particles to pieces between their medial teeth at the labium, (3) pushing particles into the oesophagus with a group of brush-like hairs, and (4) brushing the dorsal margins of the maxillae. Movable epipharyngeal blades clean the mandibular combs, while the mandibles are opening, retaining collected particles in the preoral cavity. The oesophagus imbibes water from the preoral cavity, presses it through its filter structures and ejects it laterally to the preoral cavity.

In addition to filtering food particles from the water, the 3rd and the 4th-instar larvae are also adapted to bottom feeding. These instars are characterized by flabellar hairs of variable lengths including groups of shortened stout hairs with apically thickened serrations. The maxillae of the 3rd and 4th-instar larvae have scraping dents on their medial margin and a short tuft of serrated and unserrated hairs. Adaptions for bottom feeding are not present in the 1st-instar larvae. The 2nd-instar larva represents an intermediate type. The adaption to different food sources was also shown in behavioral experiments.

**R2.3.** SOME MORPHOLOGICAL STRUCTURES ASSOCIATED WITH THE ANTENNAE  
**3** OF THE COTTON LEAFWORM, SPODOPTERA LITTORALIS B.

I.M.Helal and A.A.ABDEL GAWAAD

Faculty of Agric. Alex.Univ. and Fac.of Agric. Moshtohar

Scanning electron microscopy studies occur on the antennae of male and female of the noctuid moth Spodoptera littoralis B. Seven types of sensillum occur on the antenna of both sexes, sensilla auricillica, 3 types of sensilla trichodea, sensilla styloconica, small chemoreceptor pegs, sensilla chaetica, sensilla coeloconica and sensilla squamiformia.

Sexual dimorphism is mainly restricted at the apical segment in the number of the small chemoreceptor pegs, sensilla styloconica and sensilla chaetica which can easily distinguished from the sensilla trichodea by having longitudinal and annular grooves in their surfaces. Also, for the first time in Lepidopterous insects the small chemoreceptor located in the sensillar field.

## R2.3. THE EXTERNAL SENSILLA OF FEMALE TRICHOGRAMMA MINUTUM RILEY

4

J.M. SCHMIDT and J.J.B. SMITH

Department of Zoology, University of Toronto, Toronto, Ont., CANADA M5S 1A1

Females of the parasitic wasp Trichogramma minutum evaluate host acceptability using both tactile and chemical senses. Scanning electron microscope studies have shown that there are two morphologically distinct types of sensilla basiconica located on the antennal filament which probably serve as olfactory or gustatory chemosensilla. The majority of these sensilla are located in such a way that they contact the surface of the host during examination. In addition, the antennal tip is provided with two types of sensilla trichoidea which appear to be mechanosensory. Hairplates occur at the pedicel-scapel and scapel antennal joints, in the cervical region, in the wing bases, and on the coxae. They are homologous to those described for other Hymenoptera, but show considerable miniturization. Most consist of only 2-3 uniquely oriented sensilla. It is proposed that the information these hairplates provide about the relative position of body parts is used not only in gravity detection and the control of position and movement, but also in determining the acceptability and size of a potential host.

## R2.3. SENSORY EQUIPMENT AND HUNTING BEHAVIOUR OF CARABID BEETLES WHICH FEED ON COLLEMBOLA

5

THOMAS BAUER. Zoologisches  
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Within the Carabidae there are a variety of strategies used to overcome the flight mechanism of Collembola.

Some diurnal species (e.g. Asaphidion sp., Notiophilus sp.) hunt exclusively by means of visual cues. Their hunting success is correlated with the resolving power within their binocular field of vision. The larvae of Carabidae find their prey by chemical cues. Here the attack is triggered by contact with the prey. The larva of Notiophilus biguttatus succeeds in hunting springtails because this contact, by the trichobothria of the head, is too gentle to provoke the flight mechanism of the springtail. A special apparatus for hunting Collembola was found in Loricera sp. and Leistus sp. Loricera strikes the antennae together and encloses the prey within enlarged setae on the proximal antennomeres and on the ventral surface of the head. The Leistus species have a circular, fence-like array of strong setae bordering the concave ventral surface of the head. When a springtail is positioned beneath this cavity, the head is lowered, the prey enclosed and grasped by the mouthparts.

**R2.4.** THE STRIDULATORY APPARATUS OF MICRONECTINAE  
**1** (HETEROPTERA, CORIXIDAE)

JANSSON, ANTTI

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SF-00100 Helsinki 10, Finland

For nearly 100 years it has been known that males of the old world genus Micronecta can produce underwater sounds. It is commonly believed that the strigil, a comb-like structure on the 6th abdominal tergite, is involved in this stridulation. In the South American genus Tenagobia, the males do not possess a strigil, and no previous reports exist about their possible stridulation.

Analysis of sounds from 4 species of Micronecta revealed that the signal structure does not correlate with morphology of the suggested apparatus. Moreover, recording of comparable signals from 3 species of Tenagobia confirmed that the strigil has nothing to do with the sound production of Micronectinae.

SEM investigation showed that males of both Micronecta and Tenagobia have well developed ridges on a projection located in the basal part of the right paramere. As these corixids have strong muscles for rotating the genital capsule, they can scrape the base of the right paramere over 1 or 2 ridges situated on the inside of the pocket formed by the right lobe of the 8th segment. Signal structure correlates with morphology of this apparatus, and observations on live specimens during stridulation confirmed that the sounds originate at the tip of the abdomen.

**R2.4.** CUTICLE STRUCTURE AND COLOUR IN CICINDELA  
**2**

DIETRICH MOSSAKOWSKI

UNIVERSITÄT BREMEN, NW 2, POSTFACH 330 440, D-2800 BREMEN 33

The colour impression varies from point to point looking at the cuticle surface of tiger beetles, eg. Cicindela campestris Linnaeus. There are three types of cuticle colours in Cicindela: A pigment and two types of structural colours. Structural white spots and colours produced by multilayer systems of the rhabdomere type are dominant. The different parts of the cuticle are described by SEM and TEM micrographs. Reflectance measurement are carried out over a wide range of wavelengths. Calculations of the reflectance curves are done by equations for the non-ideal type of multilayer reflectors.

## R2.4. ON THE FUNCTION OF WARNING COULORS IN INSECTS

2

W. Schuler

II. Zoologisches Institut, Berliner Straße 28, D-3400 Göttingen, Germany

Birds normally have to learn to avoid warningly coloured insects. However, even naive birds reject such prey at a higher rate than non-warningly coloured prey items (Coppinger, Am. Nat. 104, 323, 1970; Schuler, Z. Tierpsychol. 58, 66, 1982). New experiments using insect dummies demonstrate that warning colours even without distastefulness inhibit the prey-attack of young chicks. Further experiments in which distastefulness was either paired with a black and yellow pattern or with a plain green coloration indicate that chicks are pre-programmed to learn to avoid black and yellow coloured prey. It will be discussed whether this is an adaptation on the bird's side, and to what extend warning colours can enhance the effect of chemical defences.

## S2.1. INTRODUCTION

A. P. GUPTA

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Evidence will be presented that the insect brain consists of also tetrocerebrum. The composition of the brain and the terminal ganglia and the continuity of the sensory pathways, which begins during the embryonic stage and continues through to the adult stage, will be discussed. It will be concluded that certain aspects of postembryonic development of the brain continue even after adult emergence. Differences in the postembryonic development of the visual systems of hemimetabolous and holometabolous insects will be demonstrated. It is known that the corpora pedunculata (CP) vary in size in various Orders, but this variation does not parallel the hexapod phylogeny. The significance of the constant connection patterns, in terms of these CPs and the central bodies will be discussed. The optic lobes show ultrastructural differences in various Orders, with a phylogenetic trend from the primitive to the highly evolved Orders. It will be demonstrated that in 2 blind cave beetles, the large size of the CP is not correlated with optic acitivity. The functional anatomy of the deutocerebrum, including dorsal and antennal lobes and the interneurons connecting it to other brain parts, and its role in pheromone perception will be discussed. Finally, evidence will be presented to show that localized inhibition of brain acetylcholinesterase (AChE) is not crucial for death of an insect during insecticidal poisoning. And that some brain enzymes behave kinetically differently in insects of various Orders.



## **S2.1. EVOLUTION OF THE INSECT BRAIN, WITH SPECIAL REFERENCE TO THE SO-CALLED**

### **2 TRITOCEREBRON**

CHAUDONNERET J. (Laboratoire de Biologie animale et générale, Université de DIJON, 6 boulevard Gabriel, 21100 DIJON, FRANCE)

There are four nervous centres in the suboesophageal ganglion of Collembolans. The anteriormost (= tetrocerebron) is clearly distinct from the mandibular one and has its own commissure. The tritocerebron is located in the inferior part of the peristomodeal connective, widely behind the deutocerebron; its commissure is free in front of the suboesophageal ganglion. The ventral root of the frontal ganglion (= frontal ganglion connective) is connected by halves with both these nervous centres.

In the suboesophageal ganglion of the other Insects, there are only the three classical gnathal centres. The tetrocerebron has reached the peristomodeal connective and comes near to the tritocerebron, although this one goes up too. According to diverse factors (such as the systematic position of the Insect considered, the length of its peristomodeal connective, prognathism...), these two nervous centres join more or less narrowly side by side and draw nearer to the deutocerebron. In any case, the ventral root of the frontal ganglion is connected with the trito- and tetrocerebral nervous centres ; its point of emergence from the central nervous system varies according to the situation of these two neuromeres. These two neuromeres always have their own commissure, but fusions may occur in different ways ; pseudo-commissures may also appear.

## **S2.1. ASPECTS OF EMBRYONIC AND POSTEMBRYONIC BRAIN DEVELOPMENT**

### **3**

JOHN S. EDWARDS, Zoology Department, University of Washington,  
Seattle, WA 98195 USA

The pervasive conservatism of central nervous system structure throughout the Hexapoda and beyond allows for broad interpretation of brain development from relatively few known examples. Several aspects of development will be addressed: (1) The uniformity of the repeating metameric pattern of neuroblasts in thoracic and anterior abdominal embryonic segments may not extend to the anterior and posterior extremities. Thus, interpretation of segmental composition of the brain and terminal ganglia is problematic. (2) Pathways for sensory projections to the brain from the periphery are first established by embryonic pioneer fibers. Pathways so formed are conserved through metamorphosis, providing continuity and guidance for adult sensory neurons. (3) As with other developmental processes, postembryonic brain development does not conclude with the final molt; localized neuronal proliferation, cell death and resorption proceed through early adult life.

Supported by NIH Grant NB07778.

## S2.1. STRUCTURE AND FUNCTION OF THE PROTOCEREBRUM OF AN INSECT

4

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Despite many early anatomical and electrophysiological studies of the neurons of the protocerebrum of the insect brain invertebrate neurobiologists have had remarkably little success in identifying the functional roles of the protocerebrum's constituent neuropils. Recent combined anatomical and neurophysiological studies suggest that there are marked differences in the connectivity of the same neuropile areas and in the response patterns of homologous neurons in different insect species.

This presentation will review the diversity of connection and response found amongst interneuropilar interneurons and discuss the significance of the constant pattern of connection within certain neuropils. It is possible to conclude that previous thinking concerning the division of function within the brain has been hampered by the view that the insect brain demonstrates little novelty in interspecific design. New evidence allows us to speculate upon the meaning of the constant connection patterns illustrated by the central and mushroom bodies and to point to fruitful directions for further anatomical and physiological endeavour.

## S2.1. ANATOMY AND THE ULTRASTRUCTURE OF THE OPTIC LOBES

5

KARL KRAL

Department of Zoology, University of Graz, A-8010 Graz, Austria

My presentation will be concerned with the gross anatomical and ultrastructural differences in the optic lobes of various insect orders. There are many phylogenetic trends that can be seen in the evolution from the primitive to the highly advanced insects. In particular, it will be investigated to what extent the organization of the optic ganglia in insects with eyes of apposition optics differs from that in insects with eyes of superposition optics. Besides structural differences there are also differences in the postembryonal development of the visual system between e.g. an ancient hemimetabolic insect such as the cockroach and a highly advanced holometabolic insect such as an dipteran fly. This topic will be analyzed by giving a detailed description of the structural differentiation of the neuropiles in the peripheral optic ganglia, including the formation of retina-lamina projections and the establishment of specific connections between differentiating neurones.

## 52.1. 6

### NEURAL ARCHITECTURE OF A MOTION COMPUTATION CENTER IN THE FLY VISUAL SYSTEM

K. HAUSEN

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The course-stabilizing optomotor responses in flies are controlled by a system of large interneurons, which is located in the lobula plate, and which encodes retinal motion patterns perceived by the animal during flight. The system consists of 40-50 tangential cells all of which are directionally-selective motion-sensitive elements. Number, structural features and arrangement of the cells in the lobula plate are invariant in all animals. Anatomically, the tangential cells can be classified as local interneurons, bilateral connection neurons to the contralateral optic lobe and output neurons. The latter are synaptically coupled to descending neurons projecting into the motor centers of the fly. Within the lobula plate, the cells are arranged in four directionality layers containing elements sensitive to progressive, regressive, upward and downward motion, respectively. The receptive fields and spatial sensitivity distributions of the cells are determined by their dendritic territories and branching patterns. Synaptic interactions between both lobula plates lead to enhanced sensitivities of the cells for binocular rotatory motions around the body axes. Lesion experiments demonstrate that the output cells of the lobula plate control the generation of optomotor flight torque.

## 52.1. 7

### ULTRASTRUCTURAL CHANGES IN THE PROTOCEREBRUM OF BLIND CAVE BEETLES, GLASICAVICOLA BATHYSCIOIDES AND NEAPHAENOPS TELLKAMPFII.

<sup>1</sup>Joseph R. Larsen, <sup>2</sup>Gary M. Booth, and <sup>3</sup>Robert Perkes

<sup>1</sup>University of Illinois, Urbana, IL; <sup>2</sup>Brigham Young University, Provo, UT,

<sup>3</sup>Ricks College, Rexburg, ID, U.S.A.

Neaphaenops tellkampfi and Glasicavicola bathyscioides (Carabidae) were collected respectively from Hart County, Kentucky, and the Lava Ice Caves of central Idaho. Both of these cave beetles have complete external absence of eyes. The brains of N. tellkampfi and G. bathyscioides have been studied at the microscopic level. Particular attention has been paid to the protocerebrum. A remarkable feature of the brain is the corpora pedunculata, which dominates the entire brain of both insects. Its large size would suggest no relationship to optic activity as suggested by previous authors. No optic lobes were observed in either beetle. There may, however, be a vestigial optic tubercle in N. tellkampfi. Connections between the central complex and other parts of the brain appear to be few in number. There are chiasmatic fibers connecting the elipsoid body to the beta lobes, going to the single ventral tubercle in N. tellkampfi. The elipsoid body and the ventral tubercle appear to be absent in G. bathyscioides. There are accessory lobes in N. tellkampfi; accessory lobes are not apparent in G. bathyscioides. A bifurcated olfactoria globularis going on either side of the accessory lobe appears to be unique to N. tellkampfi. This is not observed in G. bathyscioides or normal beetles with eyes. The subesophageal ganglion is large in both blind cave beetles. Fiber tracks have been observed between the calyx and pons cereberalis, calyx and central body, and between the calyx and antenna lobe. The brain of N. tellkampfi appears to be more complex than the brain of G. bathyscioides.

F.W.SCHÜRMANN

I.Zoologisches Institut, Univ.Göttingen, F.R.Germany

Some outlines of the architecture of the deutocerebrum and its relations to other brain parts are drawn from the investigation of Golgi preparations, cobalt-chloride-backfills, lucifer yellow stains of single cells, transmitter histochemistry and electron microscopy. Antennal lobes are composed of sensory fibres, local interneurons and other relay interneurons connected in the glomeruli in a complex order. Sensory fibres converge on interneurons and receive presynaptic input themselves. A complex synaptic interaction pattern can be derived from the distribution of neuromodulators (dopamine, serotonin) too. Interneurons connect the deutocerebrum with distinct parts of different brain regions. The dorsal lobes of the deutocerebrum have to be considered as a motor centre and a main integration area of the brain for ascending and descending elements and wide field brain interneurons.

## S2.1. THE INSECT BRAIN: ORGANIZATION OF DEUTCEREBRAL SENSORY 9 INTEGRATION CENTERS AND PROTOCEREBRAL "HIGHER CENTERS"

N.J.STRAUSFELD<sup>1</sup>, H.DUVE., A.THORPE<sup>2</sup>, J.P.BACON<sup>3</sup>. 1.EMBL,D-69 Heidelberg,FRG. 2.School of Biology,Queen Mary College,Mile End Road,London,U.K. 3. Zoologisches Institut. Rheinsprung 9, Basel, Switzerland.

Insect CNS comprises preoral (supra-) and postoral (suboesophageal, thoracic/abdominal) neuropils. Supraoesophageal brain is divided into the anterior protocerebrum succeeded by the deutocerebrum. Both are distinguished by their characteristic neuronal arrangements. The deutocerebrum consists of sensory processing lobes (antennal & optic) connected to central multimodal integration areas, the cores of which are discrete clusters of descending neurons leading to thoracic/abdominal ganglia. Certain afferents arising in the mouthparts, antennae or from head hairs also lead onto descending neuron dendrites. In contrast, the protocerebrum comprises highly structured columnar neuropils (central and mushroom bodies) receiving relays from deutocerebral and suboesophageal sensory neuropils. These relays also extend into the dendritic domains of protocerebral peptidergic neurons, some projecting to the corpora cardiaca and others (intrinsic) invading central body or deutocerebral neuropils. Outputs from mushroom bodies and from the central body loop back into deutocerebral integration centers at descending neuron clusters. The emerging picture of the brain is that the deutocerebrum is analogous to segmental ganglia whereas the protocerebrum provides parallel multimodal pathways whose organization is a unique cephalic development.

**S2.1.** Response specificity to pheromone and other odors by neurons  
**10** in the deutocerebrum

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The function of the neurons of the deutocerebrum has so far been examined only in a few species of insects. They have been described with respect to the spectrum of stimuli to which they respond, their intensity - response curves and their excitation pattern after natural stimulation of the antenna or electrical stimulation of the antennal nerve.

Response characteristics also depend on whether inputs converge from similar receptors distributed over the whole antenna or from different receptor types (olfactory and mechanoreceptors). In some cases physiological grouping of neurones is echoed by morphological differences. Results from cockroaches, ants, bees and moths are compared.

**S2.1.** HISTOCHEMISTRY OF ACETYLCHOLINESTERASE IN THE INSECT BRAIN  
**11**

GARY M. BOOTH AND JOSEPH R. LARSEN  
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Studies of the insect brain and other parts of the insect central nervous system (CNS) have been of enormous importance in understanding the physiological properties of a variety of enzymes. For example, acetylcholinesterase (AChE) is one of the most important enzymes found in the insect CNS since it is the target-site of organophosphorus and carbamate insecticides. However, there are numerous examples where low levels of insect brain AChE inhibition have been observed during early symptoms of poisoning and sometimes even at death. These data and other published information suggest that localized AChE inhibition in the thoracic ganglia of insects may be more important in causing death than quantitative inhibition of insect brain AChE even though some insect brains (e.g. houseflies) contain more AChE than other parts of the animal. Clearly, there has been too much emphasis on the design of anticholinesterase insecticides and too little work directed at the functional morphology of the brain and other parts of the CNS. Furthermore, kinetic work on insect brain AChE shows different affinities for the same substrate for different insects. For example, there was no significant difference in the affinity of cricket-brain AChE and bovine erythrocyte AChE for the substrate acetylthiocholine, but the affinity of housefly-brain AChE for the substrate was 10 times that of the other two enzymes. Therefore, it appears that even the same enzyme found in insects of different Orders will behave kinetically differently.

## §2.2. INSECT SENSILLA: GENERAL STRUCTURE AND ADAPTATIONS TO 1 SPECIAL FUNCTIONS.

H. ALTNER

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A survey of the different types of insect sensilla as defined by modality-specific stimulus transmitting structures is presented here. It will further be shown that certain deviations from the general type can be understood as phylogenetic reconstructions correlated with functional specializations: certain units of sensilla (1) change from extero- to enteroceptors, (2) now respond to only quite restricted stimuli within a modality or (3) correlated with gross changes in antennal function undergo stepwise reduction.

## §2.2. TASTE HAIR DEVELOPMENT 2

J.J. DE KRAMER, MPIV, 8131 Seewiesen, West Germany

L.G. VAN DER MOLEN, Zoological Laboratory, University of  
Leiden, the Netherlands.

To elucidate sensillar formation, developmental stages of taste hairs on the labellum of *Calliphora vicina* were studied.

In early developmental stages, prospective sensillar cells can be distinguished from other hypodermic cells both by their early loss of contact with the ecdysial sheath and by their microtubule content. Later the apices of all cells involved in sensillar construction taper and the sensillum as a whole acquires its pear-shaped form. Before outgrowth of the hair centrioles are found near the apex of the sensory neurons. These centrioles sink into the neurons till about halfway the apex and nucleus, where after a lateral contact with the membrane of the neurons is established.

The dendrites are the first parts of the hair to grow out, after some time they are tracked and enveloped by the trichogen cell. Part of the dendrites protrudes the tip of the hair when sclerotisation starts. This part is sealed off by a plug. Wax-canal like structures are observed in this plug. No signs of formation of a second pore in the hair wall has been observed.

## **S2.2.** SENSILLA OF BLOOD-SUCKING INSECTS **3**

SUSAN B. MCIVER

Information on functional morphology and roles in behavior of sensilla of blood-sucking insects is summarized and discussed in relation to results of studies on insects with other feeding behaviors. In addition two comparisons are made within blood-sucking insects: (1) between those species which feed only on blood and those which feed on both blood and nectar and (2) between those species which live on the host and those which must locate the host from a distance.

## **S2.2.** STIMULUS TRANSMITTING STRUCTURES IN INSECT OLFACTORY SENSILLA **4**

THOMAS A. KEIL

MPI für Verhaltensphysiologie, D-8131 Seewiesen (FRG)

Insect olfactory sensilla are characterized by pore systems which traverse their cuticle. Single-walled sensilla (e.g. the pheromone sensitive trichoid sensilla of moths and the basiconic sensilla which often are sensitive to food odours) have pores with pore tubules resembling the wax canal filaments of other insect cuticles. These pore tubules are about 20 nm in diameter and reach for up to 350 nm into the hair lumen, often contacting the dendritic membranes but mostly ending free. Similar to the dendritic membranes, they are covered by a polyanionic surface coat which has been demonstrated by means of cationic markers. Double-walled sensilla (e.g. the coeloconic sensilla which often are sensitive to food odours) are characterized by an inner hair wall enclosing the dendrites, which is connected with the outer hair wall by hollow spokes continuous with the hair lumen.

S2.2.  
5FUNCTIONAL MORPHOLOGY OF AUXILIARY CELLS  
IN INSECT SENSILLA

R.A. STEINBRECHT

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Three auxiliary cells (sheath cells) are almost always associated with the receptor cells in insect sensilla. During development they are responsible for the formation of the cuticular and related parts of the sensillum, but apart from this well established morphogenetic role, their function is still largely hypothetical. New data from fine structural, morphometric, and histochemical studies are presented, including X-ray microanalysis of the electrolyte distribution. These are discussed in relation to present hypotheses on auxiliary cell function.

S2.2.  
6 EMBRYONIC DEVELOPMENT OF CERCAL SENSORY RECEPTORS AND ITS  
RELATION TO MOLTING HORMONE LEVELS.

W. GNATZY and F. ROMER

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and Inst.f. Zoologie, Universität, Saarstr.21, D-6500 Mainz, FRG

The present study is concerned with the following aspects of embryonic development in sensory receptors (contact chemoreceptors) on the abdominal cerci of the cricket *Gryllus bimaculatus*: I. the origin, II. the embryonic molt, and III. parallel changes in the ecdysteroid level.



## **S2.2.** THE PRIMARY PROCESS OF HYGRORECEPTORS IN INSECTS. **7**

F. YOKOHARI

Biol. Laboratory, Faculty of Science, Fukuoka University  
Fukuoka 814-01, Japan

## **S2.3.** RECENT ADVANCES ON INSECT COMPOUND EYE **1**

G. ADRIAN HORRIDGE

Australian National University, PO Box 475, CANBERRA 2601, Australia

The paper will be a summary of recent work on the relation between the anatomy, the optics and the responses of several selected insect eyes. Hopefully, the report will be on work done on corneal cone eyes of certain groups of beetles from observations made in 1983 and early 1984.

## 52.3. RHABDOM STRUCTURE AND THE CAPABILITY OF THE BACKSWIMMER TO 2 RECOGNIZE LIGHT POLARIZED BY REFLECTION ON WATER SURFACES

RUDOLF SCHWIND Institut für Zoologie der Universität Regensburg  
84 Regensburg, Bundesrepublik Deutschland

In a small ventral region in the compound eye of the backswimmer Notonecta glauca, there is a special orientation of the microvilli of the two central rhabdomeres. In the dorsal eye region the microvilli of these rhabdomeres are aligned with one another. In the small ventral region these microvilli are perpendicular to one another. In ommatidia looking forward the microvilli of one of the two central rhabdomeres are almost exactly in parallel with the median plane of the animal, and those of the other, almost exactly at right angles to the median plane.

The results of microspectrophotometric measurements and of behavioral experiments suggest that the central visual cells of the ventral eye region serve as a two-channel analyzer system, enabling the animal to distinguish polarized UV-light reflected by a water surface from unpolarized UV-light.

## 52.3. ULTRASTRUCTURE AND ADAPTATION OF THE APPPOSITION EYE OF 3 AGLAIS URTICAE L. (LEPIDOPTERA)

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Serial sectioning of the latero-frontal, slightly ventral eye region reveals a type I ommatidium without any torsion along the ommatidial axis. Its sensory part is composed of nine retinula receptor cells; eight of which belong to three different types of receptors and compose the main part of the rhabdom; the ninth receptor forms only a small part of the rhabdomal base. Microvilli-bundles of two opposing receptor cells alternate at angle  $\alpha$ . - Dorsally, two marginal ommatidial rows are ommatidia of type II: Cross sections of their rhabdomes are nearly double the area of type I and their rhabdomeres are arranged exactly perpendicular to one another.

Light- and dark-adaptation results in pigment migration in the receptor cells. Horizontal migration is stronger than vertical. - Monochromatic adaptation results in a special sensitivity of four diagonally arranged receptor cells  $\lambda \geq 520$  nm.

The functional significance of these facts is discussed.

## 52.3. MORPHOLOGICAL DIFFERENTIATION AND FUNCTIONAL SPECIALISATION 4 IN THE DIPTERAN RETINA

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The eyes of higher Diptera characteristically show open rhabdoms (6 peripheral visual rhabdomeres R1-6 surrounding the 2 fused central rhabdomeres R7 & 8 in each ommatidium). Dependent on the eye region, the retina is differentiated structurally: Whereas the fine morphology and twisting pattern of rhabdomeres R1-6 is uniform, there are 7 morphological types of central rhabdomeres in total, each with distinct rhabdomere size, length, and twisting pattern. In *Calliphora* and *Musca* correlations can be made with an equal number of functional types of R7/8. According to the distribution of the various types R7/8, at least 6 different eye regions with different functional characteristics can be distinguished, in some cases also special neuronal pathways. A comparable retinal structure and differentiation is also due for Tabanids however their central rhabdomeres are untwisted. In contrast to this is the retina of Nematocera, with more or less fused rhabdoms and other divergent structural features, especially an unique combination of certain visual cells with identical functional morphology within the retina.

## 52.3. THE ORGANIZATION OF VISUAL INTERNEURONS 5 ONTO DESCENDING PATHWAYS FROM THE BRAIN

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In the lobula of the blowfly (*Calliphora*) visual interneurons are organized so that they either represent the entire visual field or only a certain part of it. The former are distributed as palisades of small-field cells across the whole neuropil, whereas the latter consist of local assemblies of small-field cells or large uniquely identifiable tangential neurons, both restricted to a particular neuropil area. Generally, axons from each cell type segregate out into bundles that terminate onto characteristic domains of a descending neuron's dendritic tree. The anatomical evidence is that parallel visual processing by cells in retinotopic columns is sorted onto lobula interneurons that interact at the dendritic tree of the descending neuron. This organization resembles that of axons derived from different sensory systems converging onto follower neurons. The structural basis of the interaction between lobula output neurons and descending neurons is exemplified by two classes of cells: the sex-specific neurons, representing a frontal area of the retina, and the polarized light detector interneurons, representing a dorsal and frontal rim of specialized ommatidia. Both project to specific parts of certain descending neurons whose main branches receive inputs representing the whole of the visual field.

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In flies, cobalt ion back-filling reveals specific neuronal connectivities within the brain and thoracic ganglia. In Musca and Calliphora giant motion sensitive neurons in the optic lobes (VS and HS cells) are cobalt-coupled to assemblies of premotor interneurons the axons of which terminate in thoracic ganglia. Fine structural analysis of connexions demonstrates that besides chemical synapses there also exist gap junction-like membrane contacts between cobalt-coupled visual and descending neurons. Functional pathways so resolved illustrate the divergence of visual interneurons onto many output pathways from the brain to a number of motor centres in the thoracic ganglia.

## S2.3. SEROTONERGIC NEURONS IN THE OPTIC LOBES OF THE BLOWFLY CALLIPHORA: 7 IMMUNOCYTOCHEMISTRY AND ULTRASTRUCTURE

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Using antibodies to serotonin (5-HT) we have demonstrated sets of immuno-reactive neurons in all the neuropil regions of the optic lobes of the blowfly Calliphora. The morphology of these neurons have been reconstructed from whole mount preparations and tissue sections. All serotonergic neurons, including those of the distalmost neuropil, the lamina, are connected to higher centers in the protocerebrum. Employing immunocytochemistry for EM, combined with Golgi-EM, HRP-EM and conventional EM we have analysed the ultrastructure of some of the serotonergic neurons. Characteristically their processes contain dense core vesicles (d.: 60-100 nm). The extensively arborizing processes of the lamina cells reside mainly outside the synaptic neuropil and appear to form no synaptic contacts, but to release their neuroactive substance non-synaptically from varicosities. In this respect the fly lamina cells differ from those of Schistocerca, Periplaneta, Apis and Cataglyphis in which the lamina cells have the bulk of their processes in the synaptic neuropil (Nässel & Klemm, Cell Tissue Res. 232, 1983; Nässel, E. Meyer, N. Klemm, in prep.). Also the pattern of 5-HT neurons in the remaining optic lobes differs between the studied insects. The total number of serotonergic neurons in the optic lobes of the studied insects is relatively low, each neuron arborizing extensively.

## 52.3. FUNCTIONAL MORPHOLOGY OF INSECT EYES IN POLARIZATION VISION

8  
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Insects species of different orders like Hymenoptera (e.g. Apis, Andrena, Ammophila), Diptera (e.g. Calliphora), and Orthoptera (e.g. Gryllus) exhibit specialized ommatidia at the dorsal rim of the compound eyes: this includes optical properties leading to enlarged visual fields, microvilli exactly aligned along the rhabdom effecting high polarizational sensitivity, increased rhabdom diameter resulting in enhanced absolute sensitivity, two populations of receptors in each ommatidium having their microvilli at right angles to each other and with short wavelength sensitivity. The functional significance in the light of anatomical, physiological and behavioral data is discussed. It is proposed that the dorsal rim area is used for the analysis of polarized skylight in navigation.

## 52.3. DEVELOPMENT FROM THE CLOSED TO THE OPEN RHABDOM IN DIPTERA

9  
(A HYPOTHESIS).

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The rhabdoms of Diptera in different groups were compared from the literature and our own ultrastructurell investigations. In addition to the closed and open rhabdom typ there exist forms, that represent intermediate stages. The present material was arranged such as to form a hypothetical development-line.

Closed rhabdoms are known in some Nematocera; open rhabdoms were found also in Nematocera and in a different style in Brachycera as well as Cyclorhapha. So far there is nothing known on the development from the closed to the open rhabdom.

There is no satisfying genealogical table of the Diptera.

The present paper is a trial and stimulation to make use of ultrastructural results for systematic classification.

## §2.3. Modification of the visual pathway of the bee by 10 environment and the social state

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Electrophysiological and histological methods are used to analyse pathways of visual information in the honey bee brain. Special emphasis is put on external and internal influences for the development of these pathways. It has been demonstrated that the color composition of the environment modifies the spectral sensitivity of the bee. This may be a result of reduced connectivity of photoreceptor cells to first order interneurons. Current research involves the question, whether the change of the social status of the bee has a corresponding change in neuronal interconnection.

## P2.- SEROTONIN-IMMUNOREACTIVE NEURONS IN THE BRAIN OF THE CRICKET 1 ACHETA DOMESTICUS

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The distribution of serotonin-immunoreactive neurons in the brain of the house cricket *Acheta domesticus* was studied by means of immunocytochemical staining using a well characterized antibody to serotonin. Immunoreactive pericarya are grouped into several clusters in the midbrain(pars intercerebralis) and in the optic lobes. Strata of immunoreactive fibres match subcompartments of the lamina and medulla. Single immunoreactive wide-field-neurons are detected in the nonglomerular areas of all brain parts. Some of these fibres enter the mushroom bodies, central body and bridge, which exhibits the highest density of immunoreactive fibres. Single immunoreactive extrinsic mushroom body neurons of different known morphological types form boutons in the calyces or fine protrusions in the lobes and peduncles. The serotonin distribution can be partly attributed to known cell types and is compared with the dopamin distribution shown with a different technique.

P2.-  
2

## EVERSIBLE VESICLES IN ONYCHOPHORA AND ARTHROPODA

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Eversible vesicles are widespread in Onychophora and among the more primitive members of the different terrestrial arthropod groups. They occur in a ventral position on the trunk segments legs or its remnants. These organs represent thin-walled sacs which can be everted by increasing haemolymph pressure into functional (i.e. everted) state and retracted by decreasing haemolymph pressure and by specialized muscles into the body cavity. The main function of the eversible vesicles is water absorption from a wet substrate. Eversible vesicles have played an important role in terrestrial adaptation during phylogenesis of Arthropoda. Comparative morphology, anatomy and function of eversible vesicles in Onychophora and Arthropoda is discussed.

P2.-  
3

## FUNCTIONAL MORPHOLOGY OF THE MALE AND FEMALE GENITALIC STRUCTURES IN ZYGAEANA FABRICIUS, 1775 (LEPIDOPTERA)

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The genitalic structures of *Zygaena* are, namely in the male, highly specialised. Dorsal and ventral rasps are attached to the aedoeagus, which have been known to change their position during copulation. The functional morphology of these 'laminae dorsales' and 'ventrales' respectively has been investigated during copulation. It has been established they are used as well for the widening of the female copulatory opening as for stimulation during copulation. Another structure, the cornuti of the vesica of the aedoeagus will come into a position which closes the entrance to the bulla seminalis and will help directing the spermatophore into the bursa copulatrix. The structures of both, male and female copulatory apparatus are shown to be closely correlated and may be interpreted as a pregamic mechanism of isolation.

P2-  
4CHICHONAL VOLCANO, ENTOMOLOGICAL  
POINT OF VIEW!

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The Chichonal Volcano irrupted 3 times during 28 March and 7 April 1982. The tephra was deposited at the rate of 0.33g/sq.m/s in the town of Teapa and 0.03g/sq.m/s in Cárdenas, Tabasco, on 4th April at 0536h. The ashfall was persistant so as to affect insect and plant life. The major components of tephra,  $\text{SiO}_2$  (50-60%) and  $\text{Al}_2\text{O}_3$  (17%), associated with alkalinity and the abrasiveness of particles, caused a severe water loss in insects. In illustrations, 3-13nm particles of ash are shown to coat the cuticle of the flea beetle, Systema s-literata, virtually incerted into the intersegmental space. They possibly perforate the intersegmental membrane as the insect moves. The insect may also ingest the material during cleaning its appandages repeatedly, as was observed, with its mouthparts. A large number of hard and soft-bodied insect were observed dead. The honeybees were particularly susceptible. The illustrations were prepared from REM-Leitz scanning electron micrographs and Ilford-PF 4 film was used for photography.

P2-  
5 DIFFERENT TYPES OF SCALES IN INSECTS - EXCLUDING THOSE  
OF LEPIDOPTERA

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In different orders of insects we can find scales. Those of Lepidoptera are best known. But in Collembola, Archaeognatha, Zygentoma, Coleoptera, Diptera ect. they can be observed too in special genera or families. The scale structure of several species was improoved by light and electron microscopy. Some scales are compact, for instance in Lepismatidae or Culicidae. Curculionidae show a narrow cavity with a non perforated wall, while in Machilidae the scales are partly constructed from a meshwork of fibrils. All scales posses longitudinal ridges. Some of the scales show interference colours. Photographs, drawings and shedules demonstrate the different structure.



P2.-  
6

RECEPTOR PROJECTION PATTERNS IN AN EYE REGION IMPORTANT  
FOR POLARIZATION VISION IN SOME INSECTS

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In the compound eye of some insects, e.g. the honey bee, Apis mellifera, the desert ant, Cataglyphis bicolor (Hymenoptera), and the cricket, Gryllus campestris (Orthoptera), specialized dorsal rim areas have been described in which the arrangement of receptor cells and rhabdomeres, the retinal pigmentation, and the structure of the cornea differ from the remainder of the eye. At least in the two Hymenopteran species the dorsal rim area is indispensable for polarization vision. Using mass impregnation and intracellular staining techniques the receptor projections of the dorsal rim area are compared with those of the rest of the eye. Differences are found with respect to the projection (lamina, medulla) and the branching pattern.

P2.-  
7

COMPARATIVE STUDIES ON THE FUNCTIONAL MORPHOLOGY OF THE TRACHEAL SYSTEM IN THE FLIGHT MOTOR OF MELOLONTHA (COLEOPTERA).

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With histological and electronical microscop technics the anatomy of the tracheal system in the metathorax of Melolontha, Pachnoda, Cicindela and Amphimallon was investigated. Contruction of tracheoles, the penetrating of tracheoles into the muscle fibers length and relation between surface of the tracheal system and the mass of muscles and the ultraoptical anatomy were presented. A 3-dimensional model of an asynchronous flight muscle and of ultra-contruction of the same will be presented.

Poster

## P2.- FINE STRUCTURAL ANALYSIS OF A TABANID EYE (CHRYSOPS 8 CAECUTIENS)

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The Tabanid retina (*Chrysops caecutiens*) shows the typical structural pattern of higher Diptera (e.g. *Calliphoridae*, *Muscidae*, *Syrphidae*) with open rhabdomeres: a trapezoidal group of 6 peripheral visual cells R1-6 in each ommatidium surrounds the fused central rhabdom built up by cells R7&8. The rhabdomeres R1-6 are twisted from distal to proximal resembling the characteristic rhabdomeric twist in higher Diptera. In contrast to *Calliphora* and *Musca*, the central rhabdomeres R7 and R8 are not twisted in the middle, equatorial eye region in Tabanids. There are 3 distinct morphological types of R7, each with different orientation of microvilli. In combination with R8, there are 2 classes of untwisted central rhabdoms. Therefore a high sensitivity to plane polarized light can be predicted in the equatorial eye region of Tabanids which is absent in the correlated eye region of other Diptera.

## P2.- INTERNEURONS REPRESENTING POLARIZED LIGHT-DETECTING AND BINOCULAR- 9 VIEWING AREAS OF CALLIPHORA'S COMPOUND EYE

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Dorsal Marginal ommatidia give rise to long visual fibres (R7, R8), whose outer segments are specialized for detecting polarized light. Their endings are cobalt-coupled to marginal assemblies of interneurons in the medulla. One subset, the marginal tangentials (Marg Tans), leads to neurosecretory cell domains in the dorsolateral protocerebrum. Another group, the marginal Y cells (Marg Y), projects to a marginal assembly of lobula neurons (Col Marg cells) and to a marginal assembly of lobula plate tangential cells (NP Tans). Col Marg axons terminate contralaterally at dendritic clusters arising from descending neurons that lead from the deutocerebrum to thoracic ganglia. Other Col Marg axons end in the contralateral marginal neuropil of the lobula and medulla. NP Tans converge with ocellar interneuron endings and endings of certain VS cells of the lobula plate. Both lobulae are linked by a system of columnar neurons whose dendritic domains and terminal arbors invade retinotopic neuropil representing the area of binocular overlap (Col Binoc 1 cells). Col Binoc 2 cells end ipsilaterally on descending neurons that also receive projections from columnar lobula assemblies representing the entire monocular visual field. Anatomical data strongly suggests that information about the pattern of polarized light is integrated at descending neurons of the deutocerebrum which also receive endings from 1) neurons relaying events in the zone of binocular overlap and 2) monocular pathways. Parallel visual pathways, converging at common descending neuron clusters, appears to be a usual feature of deutocerebral organization.

F2.-  
1

## SLOW-MOTION ANALYSIS OF FREE-FLYING DRAGONFLIES

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The movements of the wings of dragonflies are too fast for direct observation. So free-flying dragonflies were filmed with a frequency up to 500 f/s. *Aeschna cyanea* is hovering compensating instabilities by turning the thorax. The flight of *Calopteryx splendens* (Agrion s.) has two functions: locomotion and communication. Approaching a female the male beats fore- and hindwings alternating, in all other cases nearly synchronous.

Egg-laying in the genus *Sympetrum* is done mostly in tandem-flight. Thereby the male is leading and doing the main flight-work. Frogs are specialized in feeding on the egg-laying tandems.

Section 3    Cytology and Ultrastructure .....

R 3.1.    *Ultrastructure and Functioning of Tracheae and Sense Organs*  
            *(Except Sensillae)* .....

R 3.2.    *Ultrastructure and Functioning of Internal Organs* .....

R 3.3.    *Karyology* .....

S 3.1.    *The Ultrastructure of Ovarian Development* .....

S 3.2.    *Insect Cuticle* .....

P 3.        .....

### R3.1. 1

#### PHOTORECEPTORS AND GLIAL CELLS.

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For some time we have maintained a lively interest in photoreceptor (R) cells and their glia. Counting perineurial cells there are ten distinct kinds of glial cells within and around the retina and first optic neuropil of Musca. Glia and the R neurons they enfold cooperate to effect visual system development and function. A number of experimental questions have been posed regarding: (1) blood-eye barrier properties of glia; (2) their ultrastructure; (3) active zones and (4) exocytosis of neurotransmitter from light-stimulated R terminals; (5) electrical and chemical "synapses" between glial and neurons; (6) glial structural intimacies with R axons; (7) the glial-initiated degeneration of R cells in the Drosophila mutant (wrdgB<sup>KS222</sup>) and (8) what happens to the proximal (synaptic) portion of the R cells (Drosophila ora JK86 mutant) when its distal rhabdomere is absent or reduced? Most of these questions have been at least partly answered by high voltage and conventional electron microscopy, (thin sections, freeze fracture replicas, lanthanum tracer). Our ultrastructural findings provided functional insights which are detailed. The concluding example of this work is the exploration of the first optic neuropil for glial-glial and glial-neuronal membrane specializations. These data have lead to a concept of the three dimensional compartmentalization of optic cartridges of the first optic neuropil and this, in turn, can be related to lamina field potentials, intracartridge electrical inhibition and the non-decremental conduction of the graded potentials of the monopolar interneurons.

### R3.1. 2

#### THE FINE STRUCTURE OF THE SCOLOPOPHOROUS ORGANS IN THE PEDICEL OF THYSANOPTERA

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The fine structure and arrangement of the scolopidia in the pedicel of the Thysanopteran genera Thrips, Aeolothrips and Haplothrips is surprisingly uniform, although these genera belong to three families with considerable morphological differences (Thripidae, Aeolothripidae, Phlaeothripidae). In general, 32 scolopidia were seen in each pedicel. There are five groups (scoloparia) of five scolopidia and one group of six scolopidia, which belong to the Johnston's organ. In contrast to the typical structure known from most other insects, ten scolopidia of Johnston's organ in Thysanoptera have not three, but only two sense cells. Four of these scolopidia show two ciliary processes of the "thin" type, six of them have one cilium of the "thin" and one of the "thick" type.- Although amphinematic scolopidia are characteristic for Johnston's organ, two of the examined scoloparia in Thysanoptera contain one mononematic scolopidium. Because of their position, it is not probable that these scolopidia belong to the other scolopophorous organ found in the pedicel of most Neoptera, the central organ, which is characterized by mononematic scolopidia. So, the central organ is probably only represented by the remaining isolated mononematic scolopidium.

**R3.1.**  
**3** Structural Basis and Functional Significance of Tracheal Expansibility.

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After eclosion and cuticle sclerotization in adult insects, specialized tracheae and air sacs become extended and are set under tension by reduction of haemolymph volume, due to postecdysial diuresis. Periodic haemolymph reduction by heartbeat reversal causes further transient tracheal volume increase, alternatingly in the anterior and posterior body. The tracheal expansibility is facilitated by plication of the cuticular intima and in thin-walled air sacs additionally by cytoskeletal structures which are documented by TEM-micrographs. Different degree of intima plication is shown by SEM-micrographs of specimens freeze-fixed at specified physiological conditions. Different principles of traction spring mechanisms are found in the tracheal system of different insect groups but also in different parts of the same body.

The functional implications of tracheal tension are discussed.

**R3.1.**  
**4** A KERATIN-LIKE PROTEIN IN INSECT TRACHEAL TAENIDIA

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The presence in Insect tracheal taenidia of a protein having an immunological determinant common to vertebrate keratins is suggested. Taenidia positively react with a specific anti keratin serum both at fluorescent and electron microscopy level. Immunoblotting shows in tracheal preparations specificity for 3 polypeptides having a M W ranging from 62 to 43, two of them corresponding to pre-keratins. In the region of taenidia reacting with the antisera, 7-8 nm thick filaments are present. The occurrence of a keratin-like protein in Insects, and the role played in the tracheal intima are discussed.

### R3.2.

1

#### THE MIDGUT CELLS, WITH EMPHASIS ON EPITHELIAL REGENERATION DURING THE MOLT AND METAMORPHOSIS

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The midgut epithelium is surrounded by a connective sheath with collagenous fibrils and enclosing fibroblasts, muscle cells, tracheolae and neurosecretory fibers. It lays on a conspicuous basal lamina and is composed usually of two cell types: columnar and regenerative cells. Endocrine like and goblet cells also may be present. The basic structure of the columnar cells is analyzed, in relation with their multiple functions: absorption, secretion (enzymes, peritrophic membrane), ion and water transport, and sometimes accumulation (spherites). The regenerative cells are either scattered or gathered in nests or crypts. They can proliferate and differentiate to replace the functional columnar cells. This epithelial regeneration may be a continuous process or occurs suddenly at defined steps of development. Several examples of this renewal are analyzed, especially in the german cockroach (Blattella germanica), where a complete renovation of the epithelium is observed at each molt, and in the mealworm (Tenebrio molitor) where the epithelium, including the basal lamina, is replaced at the metamorphosis, with a remodelling of the connective sheath. Some experimental data are given, evidencing the interest of such models in developmental biology.

### R3.2.

2

#### ORGANIZATION OF ACTIN FILAMENTS IN THE CYTOSKELETON OF AESHNA CYANEA ENTEROCYTES.

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Thin filaments measuring 6 nm across constitute a characteristic framework in the larval enterocytes. Components of this framework are 1) the core bundles in the microvilli of the brush border and their rootlets that intermingle with 2) the filament network of the terminal web; 3) the arrays of intercisternal filaments in the subapical stacks of smooth ER, and 4) the cortical filaments along the basolateral plasma membranes. Treatment of semithin cryosections with rhodamine-phalloidin, a fluorescent probe specific for F-actin, leads to distinct labelling of the brush border, the terminal web region, the sites of ER stacks, and the basolateral cell outlines. This indicates that the above-mentioned filaments represent actin filaments.

### R3.2. FAT BODIES AND BIOLUMINESCENCE IN KEROPLATUS

3

3

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*Keroplatus tipuloides* (Diptera, Mycetophilidae) shows at the stages of mature larva and pupa a strong bioluminescence, which disappears in the adult a few hours after the last moulting.

Fat body is the structure responsible for this phenomenon, because it is able to produce light when isolated from the other organs.

Examined by electron microscopy it seems quite different in the pupa and in the adult, for the different size of lipidic inclusions, the different development of various cytoplasmic organelles and, overall, for the presence in the pupal stage of numerous inclusions containing light crystals.

### R3.2. THE ULTRASTRUCTURE AND HORMONAL CONTROL OF THE SILK GLAND OF BOMBYX MORI

4

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The silk gland of Bombyx mori secrete large amounts of fibroin and sericins. The gland consists of three divisions, each characterized by different secretory functions. The posterior silk gland cells undergo endomitosis during the larval period, and this results in highly polyploid cells. The extremely convoluted nucleus contains numerous nucleoli, and their morphology changes with changes in RNA synthesis. The cytoplasm of mature cells contains concentrated RER, Golgi complexes, and fibroin globules. The fibroin molecules synthesized on polysomes attached to the RER are transferred into the cisternal lumen, pass through the RER to Golgi complexes, fibroin globules, and enter silk layer in the gland lumen. Three types of sericin are secreted from different parts of the middle region of the silk gland. They are also observed in Golgi vacuoles, sericin globules, and silk layers in different segments of middle silk gland. The current of liquid fibroin moves through the lumen of the gland toward the spinneret. The liquid fibroin column is composed of the spherical masses of fiber, each of these contain the elementary fibroin fibers. The silk gland is a target tissue for ecdysone and juvenile hormone. The administration of ecdysterone causes various morphological changes by the treated stages during the 5th instar. By the administration in early 5th instar, the gland cells reveal similar morphological changes during larval molting stage. In the later of the 5th instar, the gland cells treated are degenerated.



### **R3.2.** **5** THE ABSORPTIVE PATHWAY OF TRIGLYCERIDE THROUGH THE LARVAL MIDGUT EPITHELIUM OF AESHNA CYANEA.

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Triolein is hydrolyzed in the midgut lumen, and the lipolytic products enter the absorptive cells by direct membrane transport presumably by simple diffusion. Ingestion of  $^{14}\text{C}$ -oleic acid is followed by acylglycerol synthesis and esterification up to triglyceride in the enterocytes. Triglyceride resynthesis leads to the accumulation of matrix lipid droplets that are devoid of a triple-layered bounding membrane. Lipid was never identified in ER cisternae, dictyosomes and exocytotic vesicles. Hence, the absorptive route does not utilize lipid compartmentalization by membranes but is exclusively in the groundplasm. Discharge into the hemolymph involves partial lipolysis into diglyceride and fatty acid which are released in morphologically invisible form, probably by direct membrane transport.

### **R3.2.** **6** ENDOCRINE CELLS IN THE MIDGUT OF Aedes Aegypti

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Scattered randomly along the epithelium of the insect midgut are cells with the ultrastructural characteristics of cells in the vertebrate gastro-entero-pancreatic endocrine system. The endocrine cells of the midgut have been shown to contain peptides immunologically similar to pancreatic polypeptide, glucagon/glicentin, and insulin. We have studied these endocrine cells, because they may release factors that regulate metabolism and digestion in the mosquito.

The endocrine cells are smaller (2-8  $\mu\text{m}$  in width) than the digestive cells and positioned basally in the epithelium. Often, the cells are flask-shaped with a thin extension to the midgut lumen and a small tuft of microvilli. Frequently, lateral extensions of the basal part of a cell contact several digestive cells. The most notable characteristic of an endocrine cell is the presence of secretory granules (approx. 100 nm in dia.) concentrated in the basal area. These granules are formed in a manner typical of cells that export peptides or proteins, and the contents of the granules are released by exocytosis. With light microscopy, we have observed cells in the mosquito midgut that are immunoreactive to antisera against bovine pancreatic polypeptide. We are testing antisera to other vertebrate peptides and combining immunocytochemistry with electron microscopy to determine the specific location of the peptides within the immunoreactive cells.

### R3.3. ULTRASTRUCTURE OF POLYTENE CHROMOSOMES

1  
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Electron microscopic studies on the thin-sectioned polytene chromosomes support the concept of differential organization of chromatin fiber in bands and interbands. A typical nucleosome-chromatosome fiber, with a diameter of 10 nm or more, seems to exist only in the chromomeres, while the interchromomeric regions of individual chromatids are composed of a thinner fibril, with diameter of only 3-5 nm. The distance of Bridges' bands, which is ca. 0.15 - 0.3  $\mu$ m even in the well-stretched regions of polytene chromosomes of *Drosophila*, indicates that the interchromomeric DNA is probably too short to contain genes. EM-localization of genes as well as the immunochemical localization of RNA-polymerases support the view that only the promoter regions of transcriptional units are probably located in interbands, while the actual coding sequences with possible introns are located in bands of polytene chromosomes.

### R3.3. EFFECT OF LEAD ACETATE ON PUFFING PATTERN OF POLYTENE CHROMOSOMES OF A FRUIT FLY DACUS ZONATUS (DIPTERA: TEPHRITIDAE)

2  
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The polytene chromosome set in Dacus zonatus Saunders is represented by six giant chromosomes, the sex chromosome (X-chromosome) being the smallest unit. During the end of third larval instar there is particular appearance of various puffs-like structures along the length of these chromosomes. The formation of puffs has been recently related with the synthesis of RNA. The puffing in polytene chromosomes can be induced by the hormone ecdysone. Recently, while studying the effect of heavy metals on the nuclear matter of these flies, it was observed that lead acetate also induced puffing in various polytene chromosomes similar to that produced by ecdysone hormone. The major difference from the latter was the appearance of a new puff in the terminal region (1B-1D) of the X-chromosome. This observation led to the conclusion that the heavy metal like lead can also induce a change in the sex-chromosome and this may lead to further reproductive anomalies in these flies.

### R3.3. STRUCTURAL AND FUNCTIONAL ASPECTS OF CHROMATIN ORGANIZATION 3 IN OOCYTE NUCLEI OF ACHETA (GRYLLIDAE).

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Oocyte nuclei of *Acheta domesticus* (panoistic ovary type) provide a particularly interesting type of organization of nuclear chromatin components. This holds in particular, since basic structural chromatin organization had been analysed by a variety of methods (see e.g., Bier, K. et al., *Chromosoma* 23, 214, 1967; Kunz, W., *Chromosoma* 26, 41, 1969; Lima-de-Faria, A., in: *Handbk.Mol. Cytol.*, (Lima-de-Faria, A. ed) p.277, 1969; Cave, M.D., in: *Insect Ultrastructure* (King, R.C., Akai, H., ed), Vol.I, p.86, 1982).

Structural arrangement of chromatin components within isolated nuclei of early-, mid-, and late-vitellogenic oocytes was analysed using Nomarski differential interference contrast microscopy. Subsequently, chromatin components were isolated by micromanipulation, fixed and sectioned for EM (c.f. Spring, H., Franke, W.W., *Eur.J. Cell Biol.* 24, 298, 1981). In addition, microisolated chromatin was analysed in Miller-type chromatin spread preparations (c.f. Trendelenburg, M.F. et al., *J.Mol.Biol.*, 108, 453, 1976; *Differentiation* 7, 133, 1977). Our results indicate, that structural changes during oogenesis can be observed for (1) amplified nucleoli, (2) lampbrush chromosomes, (3) the Binnenkörper spheres, and (4) a conspicuous ribonucleoprotein (RNP) mass.

M.F.T. is supported by a Heisenberg-Fellowship from the DFG.

### R3.3. THE FUNCTION OF THE SYNAPTONEMAL COMPLEX 5

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The three main subprocesses of meiosis, namely (i) chromosome pairing, (ii) crossing over and (iii) disjunction all depend on the presence of the synaptonemal complex (SC). The functions in which the SC participate include (1) the precise matching of homologous chromosome segments during synapsis at zygotene, (2) the resolution of entanglements of chromosomes and bivalents during synapsis, (3) nonspecific pairing of chromosomes or chromosome segments left unpaired after the preceding specific pairing phase, (4) the control of the distribution of crossing over and gene conversion. The latter function involves an initial binding of recombination nodules (RN) to the central region of the SC according to an inherent affinity pattern determined by the DNA. Following a crossover but not a gene conversion event, the SC is modified causing a reduction of the probability for additional crossovers within the length of the modified segment. (5) The stabilisation of the site of crossing over from the end of pachytene until a chromatin chiasma is organized at diakinesis.

In addition to these functions, which are common to the vast majority of organisms, species specific modifications of the SC have evolved in many insects. Among these are (1) the "elimination chromatin" of Lepidoptera, (2) the synaptonemal polycomplexes of mosquitoes and (3) the filamentous SC constituents between the sister chromatids of various grasshoppers.

It is the intention of this review to describe and discuss the multiple functions of the SC both in the course of normal meiosis and in special cases where the SC have attained a unique function.

### R3.3.

#### 6 KARYOTYPE EVOLUTION IN TETTIGONIDS (CLASS:INSECTA).

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Chromosomal analysis of seven new species and reinvestigation of five tettigonid species has been made. With this, karyotypes of nearly 160 species of tettigonids are available. We have recorded the lowest chromosome number of  $2n=12$  in Euhexacentrus annulicornis. The diploid number in this group ranges from 12 to 39. The karyotypic complement of a species may be of only biarmed or of only unarmed chromosomes or of even both types. The evolutionary diversification in tettigonid karyotype has been analysed. The role of centric fusions, tandem fusions and pericentric inversions have been recognised. Most of the species have XX:XO type of sex chromosome mechanism and a very large X chromosome. This large X chromosome is believed to have played a significant role in the karyotypic evolution of tettigonids.

### R3.3.

#### 7 CHROMOSOMES AND SEX DETERMINATION IN SEVEN SPECIES OF GRASS-HOPPER (ORTHOPTERA: ACRIDIDAE)

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The chromosome numbers of seven species of Acrididae were studied. The species were Heteracris littoralis; Acrolytus insubricus; Aiolopus thalassimus; Sphingonatus carinatus; Mioscirtus wagneri; Ochrilidae acuta and Hilethera hierichonica.

Chromosomal examination and count were made in the first meiotic division in all species the haploid chromosome numbers appeared to be 11 or 12 in the male and 12 in the female. On the basis of the haploid chromosome number it seems that these species have (XX/XO) sex chromosome mechanism. Also the evidence of supernumerary chromosome is not present.

### §3.1. 1

#### EVOLUTIONARY DIVERSITIES IN OVARIAN ORGANIZATION

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In insects three types of ovarioles are found: In panoistic ovarioles all germ cells can develop into oocytes. About 5% of all living species belong to this group generally found among 'primitive' insects. In meroistic ovarioles most germ cell descendants develop into polyploidizing nurse cells which assist the oocytes during previtellogenesis. In polytrophic meroistic ovarioles each oocyte is connected to its own sister cells (nurse cells) only, whereas in telotrophic meroistic ovarioles all nurse cells are connected finally to all oocytes. Based on the analysis of the ontogenetic development of ovarioles it is stated that the polytrophic ovary has been developed independently at least 3 times: in the Dermaptera, the common ancestors of the Paraneoptera and Holometabola, and in one flea family, the Hystrichopsyllidae. The telotrophic ovary has been developed independently in the Hemiptera, the polyphage Coleoptera, and the Raphidioptera/Megaloptera. A switch back to the panoistic type has occurred in some species of several higher developed insect groups.

### §3.1. 2

#### STRUCTURE AND PHYSIOLOGY OF THE INSECT EGG-SHELL

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Following egg maturation the egg-shell is responsible for facilitating sperm entry, providing thermal/mechanical protection for the embryo, allowing respiration without permitting dessication and finally facilitating hatching. Very intensive work has been performed for the last five years on the architecture and the physiological implications of the insect egg-shell. It is of particular interest that in spite of the diversities in size and the variations in egg-laying substrates, several common features have been revealed which underline the existence of conservative and variable structural/functional elements. These include: a) plastron respiration in those egg-shells which are facing a wet yet oxygen-rich environment, b) water-proofness via waxes in cases where excessively dry environment is present, c) covalent crosslinking through elastic bonding whenever a deformable (during oviposition) egg-shell is desirable, and d) existence of crystalline layers which are associated with specific functions.

The information accumulated so far suggests that the diversity in reproductive strategies between species is one of the major factors underlying the structural diversity which exists in the egg-shell layers and specialized regions even in closely related species.

S3.1.3 ULTRASTRUCTURAL CHANGES IN THE CHORIOTHETE OF TSETSE-FLY GLOSSINA  
MORSITANS MORSITANS DURING PREGNANCY

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Ultrastructural observations indicated that there were changes in the choriothete during pregnancy. There were more mitochondria in the cytoplasm of the pregnant choriothete than in the virgin. The mitochondria which were large and elongate were closely associated with the extensive infoldings of the lateral cytoplasmic membrane, such association being typical of cells actively involved in ionic exchange. The unusually extensive infoldings of the apical cytoplasmic membrane were not associated with mitochondria but in later stages of pregnancy accumulation of a moderately electron-dense material was observed in the lumina of the infolding. This material was similar in consistency to the one seen immediately under the cuticle.

It is concluded that the choriothete cells are involved both in ionic exchange activities and in the possible secretion of a substance.

S3.1.4 VITELLOGENESIS IN INSECTS

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It is now well established that vitellogenic oocytes in insects undergo yolk deposition by uptake of several hemolymph proteins. The primary objective of this lecture is to review some of the evidence that has brought to the recognition of the heterosynthetic nature of yolk proteins. Both the ultrastructural appearance of the oocyte cortex during vitellogenesis and the chemical identity of all hemolymph proteins contributing to the yolk will be examined in this prospective.

Much of the evidence now available indicates quite clearly that vitellogenesis in insects is a hormone controlled process. Thus, a secondary objective of this lecture is to examine whether the oocyte competence to undergo endocytic uptake is by itself dependent on a hormone availability. A final question to be examined in this context is whether a permissive role in the hormonal control on oocyte competence is played by the overlying follicle cell epithelium, presumably through metabolic coupling with the gap junctions.

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We have studied both vitellogenin (VG) synthesis by the mosquito fat body and VG internalization by the oocytes. The fat body cells, trophocytes (TR), become competent to synthesize VG as a result of JH-dependent previtellogenic development of synthetic organelles. During the VG synthetic cycle, the TR nucleolus exhibits hormone-mediated functional and morphological changes; its activity is initiated by JH and terminated by ecdysterone. We have visualized a complete VG synthetic cycle by immunofluorescence. The pathway of VG synthesis in the TR, followed by EM immunocytochemistry, shows VG synthesized on RER, processed and packaged in secretion granules in the Golgi complex, and released by exocytosis. Termination of VG synthesis is marked by autolysosomal degradation of synthetic and processing organelles.

The oocytes become competent to internalize protein as a result of JH-controlled formation of endocytotic organelles. We have used EM immunocytochemistry to demonstrate the VG-accumulative pathway: VG binds to its receptors on the specialized domain of the ooplasm, is then internalized by coated vesicles, and is transported into accumulative compartments, i.e., transitional yolk bodies (TYB), where VG dissociates from its receptors. The TYB are transformed into mature yolk bodies, where VG is modified and stored as the crystalline yolk protein, vitellin. VG itself is the factor that directs both VG and non-specific proteins to the VG-accumulative pathway; in the absence of VG, non-specific proteins enter the degradative pathway.

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The oriental fruit fly is the advanced holometabolous insect possessing the polytrophic meroistic ovariole. The egg chamber is formed while the female is 3 days old. There are mostly 4 egg chambers in the vitellarium of each ovariole. Each egg chamber consists of one oocyte and 15 nurse cells surrounded by the cuboidal cells of a follicular envelope. The oocyte is morphologically distinguished from the nurse cells on the 5 days old adult and the egg is well developed on the 7 days. The egg and its interconnected cells are formed by the division of a cytotblast within the germarium of the ovariole, where there are two kinds of cells; the light and the dark cells. A thin acellular membran about 50 mu thick attaches to the surface of the ovariole from the terminal filament, through the germarium to all eggs chambers. This study is to investigate the transformation of the light and the dark cells in the germarium, the formation of egg chamber, and the interconnection of the oocyte and the nurse cells from the ovariole of this insect with the Scanning Electron Microscope and the Transmission Electron Microscope.

### **S3.2.** **1** COULD CHITIN BE DEMONSTRATED IN CUTICLE AND EGG SHELL OF THE SPIDER MITE-A COMPARISON OF DIFFERENT HISTOCHEMICAL METHODS

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Different histochemical methods for the demonstration of chitin are described and compared according to their value and range and application.

These methods include the application of FITC-labeled chitinase, ferritin-labelled chitinase, and peroxidase-labeled wheat germ agglutinin to tissue blocks and sections. Reaction products are visualised by different techniques for light and electron microscopy. On the basis of the insect cuticle with a known chitin content, the methods are tested and next, employed on the spider mite cuticle and egg shell. Occurrence and distribution of chitin in the mite are discussed with special reference to the value of the method for solving questions concerning mode of action of chitin synthesis inhibitors.

### **S3.2.** **2** COCKROACH OOTHECINS: SEQUENCE ANALYSIS OF OOTHECIN cDNAs.

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The formation of cross-linked natural structural materials in insects by the reaction of proteins with the oxidation products of phenols was first described in cockroach egg cases. The structural proteins of the egg cases are small glycine-rich proteins (oothecins) and their mRNAs are abundant in the left colleterial gland of the female cockroach. Oothecin cDNAs have been sequenced and their derived amino acid sequences obtained. They show interesting homologies with silkworm chorion proteins.



### §3.2. PROPERTIES AND DISTRIBUTION OF PROTEINS IN THE CUTICLE OF 3 THE MIGRATORY LOCUST, LOCUSTA MIGRATORIA.

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Cuticle from newly moulted locusts contains about 78 % protein and 22 % chitin. The protein fraction contains more than fifty different proteins, and most of them have molecular weights between 10 000 and 50 000 dalton, and isoelectric points above 7. The mixture of proteins extracted from cuticle is characterized by an unusually high content of alanine and a low content of amino acids with polar sidechains, features which are also present in all except one of the proteins which we have obtained pure.

Two-dimensional gel-electrophoresis of proteins from pieces of cuticle taken from various parts of the body shows that there are profound regional differences. The functional importance of these differences will be discussed.

### §3.2. INTERACTIONS BETWEEN CUTICULAR PROTEINS IN VITRO 4

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The proteins of insect cuticle vary in their relative hydrophobicity and this has been related to the mechanical properties and phylogenetic origins of the cuticle. Some of the protein components in extracts from pharate, stiff cuticle aggregate reversibly in the test-tube under various conditions. Proteins from plant cuticle do not do so but show aggregation patterns during urea-gradient electrophoresis. These interactions correlate with the different hydrophobicities of the proteins.

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Chitin, a polymer of acetylglucosamine, is a structural component of insect cuticle. It is generally associated with proteins and it can be recognized due to its fine fibrillar appearance. Cuticle secreted by epidermal cells shows multilaminate construction resulting from a time sequence production. Cuticle is divided into an outermost layer, the epicuticle which is said to be chitin deficient, and an underlying chitin-containing layer, the procuticle. Procuticle contains helicoidally arranged chitin crystallites that look like lamellae in microscope observations. In several structures or after specific treatment this lamellate arrangement cannot be observed.

To identify the nature of the components we characterized cytochemically, chemically and physically these different structures. After drastic treatment with KOH 50% at 120°C during 24 hours resistant fraction was chemically reacted with wheat germ agglutinin, an acetylglucosamine-specific lectin. Further investigations were performed by gas chromatography, infra-red spectrophotometry and X-ray diffraction. Nonfibrillar chitin was thus detected in scales, taenidial folds, imaginal wing discs and epicuticular-like layer deposited after treatment with Diflubenzuron. These results raise two questions : does structure-like inner epicuticle contain chitin and is Diflubenzuron a chitin inhibitor?

### § 3.2. THE ULTRASTRUCTURE AND DEVELOPMENT OF EPICUTICULAR INTERFERENCE 6 REFLECTORS

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Non-ideal multilayer interference reflectors of tiger beetles (*Cicindela*) were examined with transmission and scanning electron microscopy. The reflector is composed of alternating layers of electron lucent and electron dense material, located in the outer 2μ of the exoskeleton. In aspects of ultrastructure, location, reaction to solvents, and development, the reflector appears to be a manifestation of the inner epicuticle. The reflector is dispersed by dilute KOH but is insoluble in strong acid. The reflecting layers are the first components of the cuticle to be formed during the adult moult. The dense layer increases in electron and optical density during ecdysis while the wavelength of reflection increases simultaneously. It is suggested that the dense layer may contain a melanoprotein which is formed in situ. Interference reflectors with a similar morphology have been found in the cuticles of two families of iridescent Hymenoptera (Chrysididae and Apidae:Euglossinae).

### §3.2. FINE STRUCTURE AND DEVELOPMENT OF A CUTICULAR INTERFERENCE REFLECTOR

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Some butterfly pupae (e.g. of the Danaid genera Euploea and Amauris) display a spectacular golden or silvery reflectance due to multilayer interference in their cuticle. The exocuticle of the iridescent parts is transparent, while the endocuticle consists of a high number (more than 200) of alternating electron dense and electron lucent layers of different refractive index and systematically changing thickness. The optical properties of this reflector as calculated from the fine structural data assuming constructive thin film interference are well correlated with measured spectral reflectance and transmission curves. Changes of these optical properties during development and under experimental conditions are accompanied by corresponding changes in the cuticular fine structure.

### §3.2. PARTICIPATION OF THE ARYLPHORIN MANDUCIN IN THE SCLEROTIZATION OF MANDUCA SEXTA PUPAL CUTICLE

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Manducin is the tyrosine-rich larval serum protein (arylphorin) of the tobacco hornworm, Manduca sexta. When [(U-<sup>14</sup>C)-L-tyrosine]-manducin is injected into 5th instar larvae, 3% of the radioactivity are incorporated into the sclerotized cuticle of 4 days old pupae. The following observations indicate that the incorporation is due to peptide bound tyrosine: i) immunofluorescence shows the presence of manducin antigen in the cuticle; ii) (<sup>14</sup>C)-noradrenaline is detectable in hydrolysates of sclerotized cuticle after incorporation of free (U-<sup>14</sup>C)-L-tyrosine but not after incorporation of [(U-<sup>14</sup>C)-L-tyrosine]-manducin; iii) simultaneous injection of radioinactive L-tyrosine and radiolabelled manducin does not diminish the degree of incorporation of the protein; iv) manducin is not metabolized to low molecular weight fragments in the haemolymph of developing late last instar larvae and young pupae. Peptide bound tyrosine is chemically modified in the sclerotized cuticle, as shown by HPLC analysis of cuticle hydrolysates. It is concluded that manducin is incorporated into the cuticle of the developing pupa and that the protein participates in the sclerotization process.

**53.2.** Factors influencing the stabilisation of protein within  
**9** insect cuticle

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In Locusta cuticle there are strong correlations between the amounts of chitin and protein in the cuticle. The precise amounts vary depending on the type of cuticle and its stage of development. Pharate cuticle holds more protein per unit weight of chitin than does cuticle of the mature adult; mature sclerotised cuticle contains less chitin than does mature unsclerotised cuticle (such as arthrodial membrane). Removal of the influence of the chitin by preventing its deposition (using diflubenzuron and polyoxin D) results in a reduction of the amount of protein stabilised and changes its stability within the matrix. In general the heavily sclerotised regions are less affected; arthrodial membrane will not grow in the absence of chitin. It seems, from experiments in which the degree of sclerotisation was estimated from the content of ketocatechols, that it is not the degree of sclerotisation which is important in stabilising the protein, but some inherent property of the protein, possibly its hydrophobicity. Consequently, sclerotising agents although important in changing the mechanical properties of the cuticle on emergence of the insect, do not seem to influence how much protein is deposited, with or without the presence of chitin.

These findings support the view that cuticle is formed upon a scaffold of chitin which is saturated with the matrix protein.

**53.2.** GROWTH PATTERNS OF THE COCKROACH ENDOCUTICLE IN VIVO  
**10** AND IN VITRO (BLABERINAE, BLATT.)

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In cockroaches the endocuticle is deposited in a circadian (temperature-compensated) rhythm. In *Blaberus fuscus* BURMEISTER this rhythm can be synchronized by gating of the moult. After removal of the optic lobes (the pacemakers of the circadian rhythm of locomotory activity), the circadian rhythm of deposition continues. Pieces of the hind tibiae, taken immediately after moult and transplanted into the haemocoel of an imago which has completed its endocuticle growth a long time before, frequently show circadian growth patterns, too. But in some cases, the frequency of the endocuticle layers is much higher, and the deposited material resembles the structure of the exocuticle. Cultured in vitro, this growth pattern prevails; however, in rare cases circadian patterns are observed, too. Obviously, the circadian clock, controlling endocuticle deposition, resides in the hypodermis itself.

**53.2.** CUTICLE ULTRASTRUCTURE AND EFFECT OF DIFLUBENZURON DURING INTERMOULT  
**11** AND MOULT OF LAST INSTAR SPODOPTERA LITTORALIS BOISD. LARVAE.

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The ultrastructure of the intermoult of last instar S. littoralis larvae exhibits three main layers: epicuticle, procuticle and subcuticle. The epicuticle is subdivided in a cuticulin layer and an inner epicuticle. The procuticle is seen as series of oriented lamellae of chitin fibers and a protein matrix. The subcuticle is a thin layer between the oriented lamellae and the epidermis. During intermoult only the number of oriented lamellae in the procuticle increases: 5 lamellae in just ecdysed till last instar larvae to 75 three days later.

Moult events start at about 103 hrs: ecdysial droplets are formed and slightly later apolysis occurs. After deposition of cuticulin the formation of the inner epicuticle and procuticle occurs at about 136 hrs. The epidermis cells contain multivesicular bodies and fiber material. At 150 hrs oriented lamellae are formed in the procuticle. They are arising on the tops of the plaques of the microvilli.

A continuous application of a treated diet with 100 ppm diflubenzuron exhibits an inhibition of the formation of chitin fibers which are replaced by a protein matrix, giving a structureless new procuticle during intermoult and moult. Moulting events are delayed by DFB application: ecdysial droplets are formed at 124 - 136 hrs and cuticulin is deposited at 152 hrs.

**53.2.** MECHANICAL, BIOCHEMICAL, AND MORPHOLOGICAL CHANGES IN THE LARVAL  
**12** CUTICLE OF MANDUCA SEXTA

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During the final larval instar the cuticle undergoes a series of biochemical changes resulting in alterations in morphology and the mechanical properties. The synthetic pattern of cuticular proteins in the epidermis remained constant for the first two days of growth. Then on the third day some were no longer synthesized whereas several new ones including a 28 Kd protein appeared and were deposited into the cuticle that evening. Their appearance in the cuticle coincided with a ten-fold decrease in lamellar thickness. Hormonal manipulations which prevent appearance of the thin lamellae also prevent appearance of the 28 Kd cuticular protein. Cuticular extensibility had remained constant up to this stage despite the cuticle's increasing thickness resulting in a decline in the elastic modulus. It was found that the water content of the cuticle was directly related to the modulus suggesting that high cuticular extensibility could be maintained despite increasing cuticular thickness because of the progressive hydration of the cuticle. Coinciding with the appearance of the thin lamellae, cuticular extensibility started to decline and became minimal on the next day at wandering when cuticle deposition halts. On the next day axial shrinkage of the cuticle causes increased cuticular thickness and flexural stiffness converting the previously hydrostatic skeleton into a self-supporting shell in which pupation takes place. Supported by NIH and NSF to LMR and NIH Training Grant to WJW.

**S3.2.** CUTICULAR HYDROCARBONS AS SEMIOCHEMICAL CUES OF  
**13** SYMPATRIC INSECT POPULATIONS

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Intra- and inter-specific recognition and communication among social and non-social insects often depends on short-range chemoreception processes. The combination of complexity, moderate-to-low volatility, stability, and facile biosynthesis, have combined to make cuticular hydrocarbons widely utilized semiochemical cues. Recent results on the utilization of such hydrocarbons by sympatric populations of sawflies, termites and termitophiles, and ants and myrmecophiles, will be presented.

**S3.2.** COCKROACH EPICUTICULAR CHANGES FOLLOWING DECAPITATION AND DESICCATION  
**14**

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In general, decapitation increases the permeability of cockroach integument and desiccation reduces it.

At the same time, changes in the epicuticular components take place. Less free mobile lipid is present on the outer epicuticular surface following decapitation. Endocrinologically-active homogenates partially offset this effect, maintaining epicuticular lipid mobility. Predesiccation overrides these effects, lowering epicuticular mobility, even in intact insects, and homogenates are then without noticeable effect.

These results will be discussed briefly in relation to the control of integumentary permeability.

### §3.2. SEQUENCE STUDIES ON PROTEINS FROM THE CUTICLE OF THE MIGRATORY LOCUST, LOCUSTA MIGRATORIA

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Proteins isolated from the cuticle of newly moulted locusts were purified by ion exchange and gel permeation chromatography.

The NH<sub>2</sub>-terminal sequence of 10-54 amino acid residues has been determined for several of these proteins. Most of the proteins seem to belong to a unique class of structural proteins.

A characteristic feature of this protein family seems to be that the different proteins start with a variable amino-terminal region enriched with glycine and/or hydrophilic amino acid residues, followed by a region containing approximately 50% alanine showing a high degree of intra- and intermolecular sequence homology.

The sequence data obtained and their possible relation to the function of the proteins will be discussed.

### P3.- Electron microscopy of pole cells and pole cell formation in chironomid midges (Smittia spec., Chironomus anthracinus)

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In Smittia, a single pole cell forms during early cleavage (stage P<sub>1</sub>). It divides twice, giving rise to the four germ line cells (stage P<sub>4</sub>) still found in the egg larva. The pole cells of stages P<sub>1</sub> through P<sub>4</sub> are of identical architecture. The centrally located nucleus is surrounded by four zones. A narrow zone adjacent to the nuclear envelope contains ER vesicles and cisterns as well as microtubules embedded in a rather translucent matrix. Next comes a zone rich in mitochondria which may accumulate at opposite cell poles. This zone is enveloped by a broad zone containing the oosome material. The outermost zone is filled with ribosomes but near its inner border some yolk organelles, annulate lamellae and rosette shaped membrane configurations are found. These findings will be compared to the pole cell architecture of Chironomus anthracinus.

P3.-  
2

GUT MORPHOLOGY OF THE AUSTRALIAN TERMITE  
MASTOTERMES DARWINIENSIS

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Department of Biochemistry, The University of Sydney, Sydney, N.S.W. 2006

3

The cuticle in the crop of the foregut is sculptured into six large dentate plates. Large setae are dispersed over the first and second order folds and small setae are on the third order folds. There are three stages in the cycle of epithelial cell maturation in the midgut. There is a close association of mitochondria with the basal plasmalemma. The epithelium has regularly distributed regenerative crypts. Invaginations of the basal plasmalemma are very extensive and suggest fluid transport across the membranes. Small tracheoles indicating gas exchange are plentiful close to the basal lamina. The endoplasmic reticulum exists in the supranuclear cytoplasm. The Malpighian tubules have accumulations of mineral concretion forms. Small tracheoli are distributed around the tubules fairly abundantly. Epithelial cells in the region where the Malpighian tubules join the midgut contain secretory granules. Dentate plates around the anterior colon entrance are oriented so as not to hinder the flow of the lumen contents towards the posterior colon. Invaginations of the apical plasmalemma of the normal paunch epithelial cell suggest that they are involved in fluid or solute uptake from the lumen. The cuticle of the hindgut consists of areas with adhering bacteria and areas showing an even distribution of pores free of bacteria. The posterior colon has four epithelial cell types all of which show extensive differentiation for a lower order termite.

P3.- DIFFERENTIATION OF THE OOCYTE AND NURSE CELLS IN AN  
3 APTERYGOTE INSECT /CAMPODEA SP./

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Differentiated complexes of cystocytes in an apterygote insect /Campodea sp., Diplura/ are arranged in unbranched chains. Cystocyte lying approximately in the centre of a chain differentiates into the oocyte, two cells adjoining each oocyte and connected with it via cytoplasmic bridges develop into the "intermediate cells". Other cystocytes become typical "nurse cells". The intermediate cells are structurally transitional between oocytes and nurse cells. The function of these cells remains unclear, but it seems likely that their part in rRNA synthesis is limited. On the other hand, the appearance of yolk spheres in these cells, suggests a part played in formation of reserve materials.



**P3.-** THREE INTERCELLULAR JUNCTION TYPES BETWEEN THE RETINULA CELLS  
**4** IN COMPOUND EYES OF Drosophila subobscura

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The intercellular junctions between the retinula cells in compound eyes of Drosophila subobscura have been studied using transmission electron microscopic technique, freeze-etching technique and by application of tannic acid as traser of intercellular space. It has been observed the presence of three different intercellular junction types - belt desmosome, tight and septate junctions. All three junctional types are present between both retinula cells. Desmosomes and septate junctions are visible using each three applied techniques. In the region of septate junctions mitochondria of adjacent cells are very close to cell membranes. Complexe tight junctions are clearly visible on the P face replica and present on large surface of cell membranes. We have considered a possible role of coexisting tight and septate junctions between the same cell type.

**P3.-** THE TRUNK INTEGUMENT OF SABATINCA LARVAE (LEPIDOPTERA,  
**5** ZEUGLOPTERA): AN EXTRAORDINARY INSECT CUTICLE

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The trunk exocuticle of Sabatinca larvae has a peculiar honeycomb-structure. The long axes of the (liquid-filled) "cells" of the comb are normal to the underlying pro/endocuticle and each "cell" probably corresponds to one epidermal cell. The chambered exocuticle is separated from the pro/endocuticle by a liquid-filled space, at least on the dorsal body-surface. Somewhat similar chambered cuticles are known from a few non-insect arthropods (such as some halacarids and pantopods) which like the liverwort-feeding Sabatinca larvae are subjected to alternating drying and wetting.

**P3.-** THE NUCLEAR LAMINA IN DIFFERENT LARVAL TISSUES OF THE BLOW-  
**6** FLY, CALLIPHORA VICINA R.-D.

RUTH MARX, Institut für Physiologische Chemie I der Philipps-Universität, D-3550 Marburg/Lahn, Federal Republic of Germany.

The nuclear envelope consists of an outer and inner nuclear membrane, separated by a perinuclear cisterna. Adjacent to the inner nuclear membrane, an additional layer, the nuclear lamina (NL) is discernible. The NL was very conspicuous in the tissues examined of the larval blowfly (third instar). The NL appears as a 25-70 nm thick layer with either granular, fibrous or homogeneous ultrastructure, dependent on the method of fixation and staining. Differences related to the types of tissue and possibly to the developmental stage have been observed. Using phosphotungstic acid impregnation (Silverman & Glick, J.Cell.Biol. 40, 761-767, 1969), the staining properties of the NL are different from those of membranes, e.g. the endoplasmic reticulum and mitochondria as well as the inner and outer nuclear membranes. The NL is composed mainly of proteins, but other components may also be present.

**P3.-** ULTRASTRUCTURAL ORGANIZATION OF THE NEUROPILE SYNAPTIC  
**7** AREA IN THE BRAIN OF OSTRINIA NUBILALIS HUBN. IN DIAPAUSE

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Since the morphodynamic state of the organism in diapause is directly dependent on ecological factors, we decided to fixate the caterpillars immediately upon their capture in the field, which was performed in February at the temperature of -6 to -10°C. The glia cells ensheathing the axon trunks (G<sub>2</sub>) and those facing the labyrinthic system of the intercerebral haemolymphatic channels as well as axons (G<sub>3</sub>) were irregularly populated by glycogen. The appearance of vacuolar profiles within the latter was understood as an illustration of their metabolic activity. The Gray type I and II of synapses were recognized. Besides the monocular/single synaptic contacts, the multilocular/shared synaptic contacts were also noticed. The presence of the latter, found to be excitative, indicated that in addition to the "simple synaptic transmission" the "multiplied synaptic transmission" could be also formed. The finding of glycogen within the presynaptic buttons flooded by clear vesicles attracts special attention. It is supposed that the accumulated glycogen might serve as a source of energy for the initial operativeness of the synapses due to changes in the environment.

**P3.-** STORAGE OF DEFENSIVE FLUID IN ENDOCUTICULAR CAVITIES  
**8** OF ZYGAENID LARVAE (LEPIDOPTERA)

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As a defensive reaction against predators *Zygaena trifolii* (Lepidoptera, Zygaenidae) releases high viscous fluid droplets out of endocuticular cavities. The fluid contains cyanoglucosides, proteins and water. Two morphologically different types of cavities were found: the larger ones are located beneath pigment spots, the smaller ones occupy the remaining surface except the ventral region. Both types have complicated cuticular opening structures. The epidermis below the cavities does not contain specific cells or cell areas with morphological adaptations for secretion of defensive fluid. Thus, in this organism transport and maybe even production of defensive fluid is a general adaptation of each epidermal cell. According to these cellular activities, fine structural differentiations of the epidermis concerning the position of mitochondria and the structure of the Golgi complex have developed. The adaptation of this integument as a storage chamber for defensive secretion is discussed in relation to the activities of the epidermis during molt, as the reabsorption of the old and the production of the new cuticle.

**P3.-** VITELLOGENIN UPTAKE IN OVARIAN FOLLICLES OF STICK INSECT  
**9** BACILLUS ROSSII (ROSSI) (PHASMATODEA, BACILLIDAE)

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Insect oocytes undergo vitellogenesis by selective accumulation of a soluble yolk precursor -vitellogenin. The nature of the proteins involved in the process has already been identified. We have thus attempted to establish the modalities by which the oocyte is structurally modified during protein sequestration. This has been achieved through the use of freeze fracture, scanning electron microscope and thin section analyses. Based on the present findings we infer that vitellogenin in Bacillus gains access to the oocyte interior by receptor mediated endocytosis. Our data do also suggest that the oocyte is made competent to such a function through electrotonic coupling with the overlying follicle cell epithelium.

P3.-  
10

## EM MAPPING OF THE POLYTENE CHROMOSOMES OF DROSOPHILA

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3

Longitudinal thin sections of squashed salivary gland chromosomes were used for the electron microscopic revision of the camera lucida maps drawn by C.B. and P.N. Bridges about forty years ago. The higher resolution capacity of EM has increased the total number of chromomere bands especially at the distal and proximal regions of chromosome arms. The EM analyses have uncovered numerous new, tiny bands. A special attention was paid to the fine structure of certain type of "minibands" which seem to contain extremely small amount of chromatin. The bands are formed similar type of granules (polymerases?) which are abundantly found in the puffed regions. The exact location of granules at the parallel chromatids indicates that they may represent the promoter sites of transcriptional units.

P3.-  
11

## Fine Structure of Ocelli of Larval Simulium vittatum (Diptera: Simuliidae).

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Scanning and transmission electron microscopy were used to describe the structure of light and dark adapted ocelli of last instar Simulium vittatum. Two physically connected ocelli are present on each side of the head. The anterior ocellus is smaller than the posterior. Both are dorso-ventrally oriented along their long axis, have approximately 12 retinular cells and lack an expanded cuticular lens. Conspicuous rhabdoms occur in both ocelli. The rhabdom of the posterior ocellus is centrally located, compact and surrounded by a sleeve of pigment granules. The microvilli are oriented in one plane, indicative of a possible sensitivity to polarized light. Pigment granules are absent in the retinular cells of the anterior ocellus and the microvilli lack a regular orientation. Numerous cell organelles are present in both ocelli, including large lamellar whorls associated with the nuclei. These organelles are probably involved in the turnover process of the rhabdomeric membranes.



Section 4    **Physiology** .....

R 4.1.    *Chitin Synthesis Inhibitors* .....

R 4.2.    *Insect Neurophysiology* .....

R 4.3.    *Development and Diapause* .....

R 4.4.    *Nutrition and Metabolism* .....

S 4.1.    *Chitin and Benzoylphenyl Ureas* .....

S 4.2.    *Advances in Insect Neurobiology* .....

S 4.3.    *Reproductive Physiology* .....

S 4.4.    *The Ecophysiology of Aphid Polymorphism and Biotypes* .....

S 4.5.    *Insect Locomotion* .....

S 4.6.    *Acoustic Communication in Insects* .....

S 4.7.    *Vibrational Communication in Insects* .....

S 4.8.    *Insect Vision* .....

S 4.9.    *Physiological Interactions between Endoparasitic Insects and their Hosts* ..

P 4.1.- .....

P 4.3.    .....

P 4.4.- .....

P 4.7.    .....

P 4.8.- .....

P 4.9.    .....

R4.1.  
1

## CHITIN SYNTHESIS INHIBITORS

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Chitin is a major biopolymer of N-acetyl-D-glucosamine present in numerous organisms such as fungi and invertebrates. It is an essential structural element of insect cuticle and fungal cell walls. In insects, chitin is necessary to elaborate cuticle that is an external skeleton essential for muscle attachment. Since chitin is not present in plants or vertebrates, it has been considered as a suitable target for discovery of selective insecticides or fungicides. Any disruption by pesticides in chitin biosynthesis prevents insect molts and growth of fungi leading to mortality. To prevent secondary effects of xenobiotics on other organisms, only the last step of biosynthesis has to be considered as the suitable target: chitin synthetase is this specific target.

Several compounds as pyrimidine nucleoside antibiotics, captan or benzoylphenyl ureas were described or commercially used as pesticides. *In vivo*, or *in vitro* experiments were performed to study mode of action of pyrimidine nucleoside antibiotics and benzoylphenyl ureas. Hypotheses for mechanism of action will be discussed according to results of experiments. We concluded that we have to discriminate between compounds acting directly on chitin synthesis and those affecting other mechanisms.

R4.1.  
2

### EFFECT OF A NEW BENZOYLPHENYL UREA DERIVATIVE, IKI-7899, ON GROWTH AND DEVELOPMENT OF TRIBOLIUM CASTANEUM AND MUSCA DOMESTICA VICINA

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The new benzoylphenyl urea derivative, IKI-7899 [N-2,6-difluorobenzoyl-N'-4-(3-chloro-5-trifluoromethylpyridin-2-yloxy)-3,5-dichlorophenyl urea], exhibiting a unique selectivity towards insects, was reported at the last International Congress of Pesticide Chemistry (Kyoto, 1982) by Haga et al. (Ishihara Sangyo Kaisha Ltd.).

Our results indicate that IKI-7899 is more potent than diflubenzuron on larval growth, pupation and emergence of Tribolium castaneum, a very important stored-product pest. According to probit log concentration curves, IKI-7899 is about 6-fold more toxic than diflubenzuron at LC<sub>50</sub> value and about 13-fold more toxic at LC<sub>95</sub>. With similar curves in which larval weight inhibition (LI) is determined, the potency of IKI-7899 is about 8-fold greater than that of diflubenzuron at LI<sub>50</sub> value and 21-fold greater at LI<sub>95</sub>. The increased potency of IKI-7899 compared with diflubenzuron is even greater when 4th- instead of 1st-instar T. castaneum larvae are used. On the other hand, the toxicity of IKI-7899 resembles that of diflubenzuron when assayed on the house fly, Musca domestica vicina.

The biochemical and toxicological aspects of IKI-7899, as a new chitin synthesis inhibitor, on T. castaneum and M. domestica vicina, will be discussed.

R4.1.

3

THE EFFECT OF CME 134 ON *SPODOPTERA LITTORALIS* EGGS AND LARVAEK.R.S. ASCHER<sup>1</sup> and NADIA E. NEMNY<sup>1</sup><sup>1</sup>Dept of Toxicology, ARO, The Volcani Center, Bet Dagan, Israel

CME 134, a new benzoylphenyl urea chitin synthesis inhibitor, was tested against eggs of *Spodoptera littoralis* by a dipping method. The compound, though quite active as *Spodoptera* ovicide, was less active as ovicide than diflubenzuron and BAY SIR 8514. Against larvae the compound was tested by feeding treated alfalfa, topical application and contact with crystalline residues on glass, followed by observation till the adult stage. With both 200-250 and 360-440-mg larvae 100% mortality was obtained by one-day feeding of alfalfa treated with 0.15 ppm a.i. These results are much better than those obtained with diflubenzuron and BAY SIR 8514. Topical application to 100 and 200-mg larvae showed CME 134 to be about 5 and 9 times more active than BAY SIR 8514 and diflubenzuron, respectively. These differences were much greater in the contact tests. Cotton field plots were sprayed with either CME 134 or diflubenzuron formulations, leaves were collected at different intervals and fed for one day to *S. littoralis* in the laboratory. 0.0009% a.i. CME 134 residues gave complete kill of 30-50-mg larvae after 5 and 20 days, and 86% kill after 28 days of aging. With two higher concentrations, 0.003 and 0.009% a.i., complete kill was obtained in 200-250-mg larvae until 50 days after spraying. These results were much better than those obtained with diflubenzuron.

R4.1. ACTIVITY AND FATE IN LEPIDOPTERA OF CGA 112913

4

## COMPARED WITH DIFLUBENZURON

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A comparative study was made of the fate of two chitin synthesis inhibitors, CGA 112913 (IKI-7899, 1-[3,5-dichloro-4-(3-chloro-5-trifluoromethyl-2-pyridyloxy)phenyl]-3-(2,6-difluorobenzoyl)urea) and diflubenzuron, in the larvae of *Heliothis virescens* and *Spodoptera littoralis* (normal and OP-resistant strains) by using the radiolabelled compounds. Diflubenzuron disappeared more rapidly than CGA 112913 in all three types of larvae. In addition, the rate of recovery from chitin synthesis inhibition as measured by <sup>14</sup>C-glucose incorporation into chitin was much faster with diflubenzuron. We suggest that these differences are sufficient to account for the superior biological performance of CGA 112913 in the two target species investigated.



## **R4.2.** THE 'ORCHESTRATION HYPOTHESIS' OF BEHAVIOUR GENERATION

**1**

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A major question in the generation of behaviours is how the same motor neurons and interneurons can be used in a variety of different behaviours, each with its own patterns. Are there separate inter-neuronal networks for each behaviour, activated by separate command neurons? The behaviours of otherwise closely-related species can be quite different in detail. Is this because the circuitry or the distribution of commands has changed, or both? Or is there some entirely different mechanisms involved? Comparisons of circuits in related insect species shows that they are highly conserved even though the behaviours are not. Before any behaviour occurs, modulator neurons fire: these are the dorsal unpaired median (DUM) neurons, which are octopaminergic. We have found that octopamine is a potent, 5-fold sensitizer of excitatory inputs to motor and interneurons. It is probably the major determinant of the general behavioural state. Each DUM neuron is morphologically distinct, with a characteristic pattern of endings in the neuropil. The orchestration hypothesis proposes that each specific behaviour is determined by release of octopamine at discrete sites. The sites are determined by the particular modulator neurons (mainly DUM, plus a few others) which are activated. Command neuron(s) activate(s) the cluster, and this in turn determines which parts of the neural network are activated. The different clusters of modulator neurons used to generate a behaviour include common ones when common motor neurons are to be used. A long-lasting complex behaviour is brought about by a sequence of commands, each activating a different cluster of DUM neurons. The total modulator neuron population is the 'orchestra': the orchestration, read from a coded 'score' from the insect's repertoire, by command neurons, after selection in accordance with external and internal signals, determines the behaviour.

## **R4.2.** INTERNEURONES INVOLVED IN EYE CLEANING BEHAVIOUR OF

**2**

CRICKETS:

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Mechanical stimulation of the interommatidial hairs on a compound eye of crickets releases eye cleaning behaviour (ECB). The sensory axons (SA) project to the suboesophageal - (SOG) and the prothoracic ganglion (PTG) where also the motoneurones (MN) of the neck muscles are found which execute the typical head movement component of ECB which we investigated. No direct dendritic contact between the SAs and MNs exists. Our aim was to unravel the way of information transmission from the sensory system to the excitatory MN of one neck muscle (M 60 in the PTG) which discharges in an ECB specific manner. During ECB this MN is driven mainly from the SOG via interneurones. We present data about the properties of some of these interneurones.

R4.2. 4.2. THE CONTROL OF THE  
3 ASYNCHRONOUS FLIGHT MOTOR IN MELOLONTHA (COLEOPTERA).

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As in Heteroptera, Hymenoptera and Diptera the here presented results show, that in beetles is no relation between the origin of the action potentials of an asynchronous flight muscle and the contraction. Muscles with the same function (e.g. DVM<sub>1-3</sub>, SDM) fire without relationship to another. The same can be said for motoneurons of the same muscle or for muscles of each side (e.g. right or left DLM). Corresponding antagonistic muscles (e.g. DLM and DVM<sub>1-3</sub>, SDM) do not fire in a constantly changing rhythm. The direct but also asynchronous basalar muscle (downstroke) follows the same rules. Directional change induced by side wind or side light releases no unilateral change of action potential frequency. Therefore it is concluded, that the flight motor is not responsible for setting the wing stroke amplitude. The role of Ca<sup>++</sup> for start, maintenance and stop of flight is discussed.

15 min.

R4.2. CERCAL SENSORY PROJECTIONS AND GIANT INTERNEURONS IN THE  
4 APTERYGOTE INSECT Thermobia domestica (THYSANURA, LEPISMATIDAE)

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A set of giant interneurons with cell bodies in the terminal abdominal ganglion in the majority of orthopteroid insects receives mechano-sensory input from paired abdominal cerci. An apparently homologous system in the Thysanura comprises a set of four major giant interneurons that traverse each nerve cord to the thorax and beyond. Cell bodies of the giant interneurons occupy identical positions in abdominal segments 7 through 10.

In addition to the lateral cerci, input is received from the median filament, a terminal structure that carries mechanosensory sensilla identical to those of the lateral cerci. The sensory nerve from the median filament divides in the midline at the base of the appendage and each joins its lateral cercal partner. Within the neuropile projections from median and lateral appendages overlap in part.

Supported in part by NIH Grant NB107778 to JSE.

## R4.2. THE ELECTRICAL CIRCUITRY OF PHEROMONE-RECEPTORS OF 5 ANTHRAEA POLYPHEMUS

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In order to increase our understanding about the origin of (elementary) "receptor potentials" and the dynamics of the response of pheromone receptors, we investigated first the passive electrical network of chemically unstimulated olfactory sensilla.

There it could be shown that:

- 1) The apical, and not the basolateral membranes of the auxiliary cells form the dominating barrier between the receptor and haemolymph spaces.
- 2) The electrical resistance and capacitance of the apical membranes of the auxiliary cells influence the waveform of extracellularly recorded spikes.
- 3) The biphasic appearance of the spike is not caused by antidromic propagation.

Presently we are investigating the influence of pheromone stimuli on electrically and structurally defined elements of the preparation, of which results will be presented.

## R4.2. PROCESSING OF MULTIMODAL OLFACTORY INFORMATION IN THE BRAIN OF MOTHS 6

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Under pheromonal or plant odor arousal, moths utilize both visual and mechanical (wind) stimuli to anemotactically find the odor source. To initially study the olfactory pathway involved in this behavior, extracellular recordings using cobalt-filled microelectrodes were used to define the unimodal and multimodal response characteristics and morphology of individual interneurons from different levels of the brain olfactory pathway. The stimuli used to classify the modality responsiveness were: chemical stimulation of antennae by odorant-laden air puffs, mechanical stimulation of antennae by air puffs alone, and light stimulation of the entire head. In the deutocerebrum, unimodal pheromone responsive interneurons were found in the macroglomerular complex, while both unimodal and bimodal odorant and/or mechanically responsive interneurons were found in the ventral glomeruli. These antennal lobe interneurons are mostly phasotonic or phasic in their response to stimuli. More complex response patterns (phasotonic, phasic, tonic, "on", "off", and excitation and/or inhibition responses lasting tens of seconds to minutes beyond the stimulus period) and various combinations of modality responsiveness and convergence were found in protocerebral interneurons. The occurrence of interneurons exhibiting ongoing or long-term excitation and/or inhibition due to chemical, mechanical or light stimuli suggests a memory capability that would be expected to be a characteristic of the neural circuitry involved in anemotaxis.

R4.2. THE ANTENNAL AFFERENT PATHWAY OF HONEYBEE : A MORPHO-FUNCTIONAL  
7 STUDY OF SEX-DIMORPHISM, DEVELOPMENT AND MATURATION.

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The deutocerebrum (DTC) is the first relay between the first order neurones (sensory) and the second order neurones (output deutoneurones and local interneurones) of the antennal afferent pathway. At its level the bulk of chemical-olfactory - signals (intraspecific and interspecific) receives an important treatment (integration, amplification...). These information processing are restricted to specific morphologically identifiable structures, the glomeruli. A comparative study of the spatial organization of the DTC between the worker and the drone of *Apis mellifica* L. lead to demonstrate (by using a technique of passive axonal transport of cobalt ions and a quantitative morphological analysis) and important sexual dimorphism represented by large and easily identifiable glomerular complexes in the drone.

Moreover the ontogeny and maturation of the olfactory system studied on the worker bee using a combination of neurophysiological and neuroanatomical techniques show that normal maturation of the olfactory responses take place during the first 4 days following emergence, and is closely related to the sensory environment during the same period. The synaptic organization of first order and second order neurones is essentially complete 3 days before emergence. These different results are discussed in relation to the possible functional capabilities of the dual olfactory system - "specialist" and "generalist" -, and to the possible plasticity performances of the antennal olfactory system.

R4.2. THE CIRCADIAN CLOCK SYSTEM WHICH CONTROLS THE SENSITIVITY  
8 OF THE COMPOUND EYES OF BEETLES

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The compound eyes of the carabid beetle *Anthia sexguttata* are controlled by a circadian clock system which changes the sensitivity of the eyes during continuous darkness over a range of 3 log units. The circadian oscillator is located within the optic lobe. Oscillator and retina together can function as an autonomous circadian system completely independent of the rest of the CNS.

Neuroanatomical details of this system, the retinal mechanisms of adaptation involved, and the functional organization of the circadian clock as well will be described in this report.

## R4.2. 9 Synapse formation in the fly's visual system.

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Photoreceptors of the fly, Musca, form about 200 synapses which are all divergent tetrads of uniform size and predictable composition. Both the presynaptic receptor terminal and the postsynaptic spines which service its synaptic sites regulate the area of membrane over which synapses are distributed so as to establish a precise ratio between area and number. This ratio largely resists naturally-occurring differences in synaptic load found in different eye regions.

Serial EM analyses of developing stages during the last third of pupal life indicate that individual tetrads assemble cumulatively, element by element, as postsynaptic neurites contact presynaptic sites during their exploratory outgrowth. Simultaneously the synapses enlarge. The sequence with which such elements are incorporated into the postsynaptic cluster reveals the combinatorial preferences of growing neurons, rules which exclude the incorporation of most elements at most times during the life history of a synapse. Dynamic features of synaptic assembly indicate the incorporation of elements at a rate of up to one per 7 hrs. As synapses enlarge, their overall number decreases. This loss of synapses is such as to preserve a proportionality between the mean area of those synaptic sites surviving and the area of membrane allotted, on average, to each.

## R4.2. 10 Neurochemical aspects of cholinergic synapses in insects

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Acetylcholine has long been considered a major neurotransmitter in the CNS of insects. However only little is known about the neurochemistry of cholinergic transmission in insects. Such information would be of great value not only because of its toxicological implications but also because it may shed light on the mechanism of cholinergic neurotransmission in central nervous tissue, in general. Therefore two key elements of cholinergic synapses, the high affinity choline carrier and the receptors for acetylcholine, were studied.

Synaptosomes, isolated from the head ganglia of locust have been shown to accumulate choline via a high affinity sodium dependent, carrier-mediated process. The basic mechanism of choline transport was analysed in synaptosomal membrane vesicles which lack the complex energetics and compartmentation of intact nerve endings. Such membrane vesicles displayed a concentrative transport of choline with artificially created ion gradients as sole energy source. The binding of  $\alpha$ -bungarotoxin, a specific ligand for putative nicotinic acetylcholine receptors, fulfils the criteria of saturability and pharmacological specificity as required for a transmitter-receptor. Furthermore some of the monoclonal antibodies against the AChR from Torpedo cross-reacted with the binding sites from insects. The binding components were solubilized, purified by affinity chromatography and analyzed by micro-electrophoresis.

**R4.2.** THE EFFECTS OF SEVERAL DRUGS ON EPSP AT THE NEUROMUSCULAR  
**11** JUNCTION OF THE LARVAL MEALWORM, TENEBRIO MOLITOR L.

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The effects of L-glutamic acid, quisqualic acid, L-aspartic acid, acetylcholine, curare, atropine, chlordimeform, nereistoxin, fenitrothion and fenitroxon on EPSP at the neuromuscular junction of the larval mealworm, Tenebrio molitor, were studied by means of microelectrode technique. Applications of L-glutamic acid, quisqualic acid and L-aspartic acid suppressed 50% of EPSP at concentrations of  $4.2 \times 10^{-5}$  M,  $2.3 \times 10^{-5}$  M and  $1.2 \times 10^{-3}$  M, respectively, and evoked a depolarization of muscle membrane with reduction of EPSP. However, acetylcholine at  $2 \times 10^{-3}$  M did not suppress EPSP but evoked a depolarization of muscle membrane. Atropine, curare, nereistoxin and chlordimeform at a concentration of about  $2 \times 10^{-3}$  M suppressed 50% of EPSP. From the pharmacological aspect these results suggest that L-glutamic acid is an excitatory transmitter at the insect neuromuscular junction, because L-glutamic acid and quisqualic acid, an agonist of L-glutamic acid, revealed the effect at forty and eighty times lower concentrations than other drugs, respectively.

**R4.2.** DEMONSTRATION OF HOMOLOGIES BETWEEN NEURONS OF DIFFERENT INSECT SPECIES  
**12** BY IMMUNOCYTOCHEMICAL NEUROPEPTIDE CHARACTERIZATION

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The localization of lateral and median neurosecretory cell groups, consisting of presumed peptidergic neurons, seems to be rather conservative in insects and the cell types involved can be called "homologous". So far relatively few homologies between other peptidergic insect neurons have been described. Immunocytochemistry with specific peptide antisera may be useful for establishing such homologies. The hypothesis that now can be tested is the following: If part of the insect peptide recognized by the antiserum is important for the functioning of the peptide, that part of the molecule may have been relatively stable during evolution and homologous neurons containing that peptide may be revealed in different species. It seems thus likely that the Bovine Pancreatic Polypeptide-(BPP-)like neurons in the Colorado potato beetle (Veenstra and Schooneveld, 1984) are homologous to the BPP-like neurons in a blowfly (Duve and Thorpe, 1980). Similarly, Vasopressin-(VP)like neurons in the Colorado potato beetle seem to be homologous to VP-like neurons in a locust (Rémy and Girardie, 1980). It appears essential for such comparative work to use well-characterized antisera, as different antisera against the same peptide may have different specificities and thus mask possible homologies.

It seems likely that peptides which have been relatively stable during evolution and which are present in homologous neurons, have comparable functions. Thus the immunocytochemical demonstration of homologies between insect neurons may improve our knowledge of comparative insect neuroendocrinology.

R4.2.  
13

CEPHALIC NEUROENDOCRINE SYSTEM OF  
PANTALA FLAVESCENS (FABR.) LARVAE

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The neurosecretory cells in the brain are located in pars intercerebralis, ventrolateral region of protocerebrum, tritocerebral lobes and at the root of optic lobes. They are classified into A<sub>1</sub>, A<sub>2</sub>, B and C cells. The axons of neurosecretory cells of different groups form independent neurosecretory axonal pathways and that of medial, lateral and ventral neurosecretory cells of each hemisphere emerge out of the brain as a single fine nerve, the nervi corporis cardiaci, innervating the ipsilateral corpus cardiacum (CC). The CC are fusiform glistening white ventral bodies and appear as principal, while the aorta functions as the secondary neurohaemal organ. The intrinsic neurosecretory cells are intermingled with extrinsic axonal endings throughout the substance of CC. The corpora allata (CA) are elongated, oval or cylindrical bodies, situated anterolaterally to the CC and are innervated by nervi corporis allati (NCA) I from the CC and the NCA II leading to the suboesophageal ganglion. The CA undergo cyclic activity and often change from cellular to syncytial structure.

R4.2. INSECT BRAIN METABOLISM UNDER NORMOXIC AND HYPOXIC CONDITIONS  
14

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Insects have been widely used as experimental systems by neurobiologists. Little information, however, is available on the metabolic basis of nerve cell functioning in insects. Most authors silently tend to generalize the situation found in mammals. Studies during the last few years have revealed that this view is not justified. Insect nervous systems show some unique features not to be found in other systematic groups. We have studied brains of various insect species with enzymatic, microrespirometric and tracer methods under both normoxic and hypoxic conditions:

- 1) Glucose and ketone bodies are substrates for all insect brains, but some lepidoptera are able to meet the energy demand of their brains mostly by direct oxidation of fatty acids, a unique feature among nervous systems.
- 2) Insect brains store significant amounts of glycogen, they can be isolated and their respiratory metabolism can be studied in vitro.
- 3) Insect brains have a high metabolic rate, surpassing significantly that of mammals and their metabolism is strictly specialized on aerobic processes.
- 4) The metabolic response to lack of oxygen is different from that in mammals, which are rapidly killed under these conditions. In contrast to vertebrates, anoxic insect brains reduce their metabolic rate to very low levels, and many species can survive total anoxia for several hours without any lasting neuronal damage. The metabolic processes accompanying anoxia and recovery will be discussed. - Supported by Deutsche Forschungsgemeinschaft, Bonn.



**R4.2.** EFFECTS OF PERIPHERAL THERMAL STIMULATION ON SINGLE FIBRE  
**15** ACTIVITY IN THE WALKING LEGS OF A MYGALAMORPH SPIDER

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Neuronal responses to thermal stimulation of the ventral tarsus (temperature range: 25-45 °C) were recorded extracellularly from single fibres in the tibia, metatarsus and tarsus of intact walking legs of Phormictopus sp. (Araneae, Theraphosidae). Units with a static discharge frequency at room temperature (23-25 °C) showed an increase or decrease of the impulse frequency according to the changed temperature level. The activity of some fibres ceased completely between 32 °C and 40 °C. In general, responses were static at slow temperature changes and dynamic at temperature jumps. In some fibres, however, a slow temperature increase elicited an additional dynamic response at 43-45 °C which is slightly above the threshold temperature of behavioural responses in Phormictopus. All fibres were sensitive to mechanical stimuli; some units responded also to odorants (acetone, acetic acid, acetic ether) and water vapour. Responses to all stimuli were highly reproducible. Temperature coefficients of some fibres were in the range of thermosensitive units of mammals and insects ( $>> 1 \text{ imp. / s} \cdot ^\circ\text{C}$ ). We suppose that these fibres belong to bi- or multimodal receptors which mediate peripheral temperature sensations in spiders.

Supported by the Deutsche Forschungsgemeinschaft (Wu 63/7-1).

**R4.3.** UNIVOLTINE AND BIVOLTINE GENERATIONS OF OSTRINIA NUBILALIS HÜBN.  
**1** ON CORN (ZEAMAYS) IN YUGOSLAVIA

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Experimental researches of the development of Ostrinia nubilalis Hübn. in the laboratory, researches in the field, and with ferromone traps in Yugoslavia, showed that, depending on eclosion of butterflies, two generations appear on corn. Caterpillars which developed from the butterflies flew out in May and June (relation of day and night 15/9) will give the next generation of butterflies by the end of August and the beginning of September (14/10), and their caterpillars will continue to feed themselves on the late sorts of corn till October. Caterpillars, which, develop from the eggs of the first generation of butterflies, in the fifth stage are caught by the relation of day-night 14,5/9,5 in August, so they enter the stage of diapause. In October (12/12) the caterpillars of second generation join the former one, together with the part of population which has reached the fifth stage of the development. In that way, the population which will give adults next year is formed.



**R4.3.** THE EFFECT OF ENVIRONMENTAL FACTORS ON EMBRYOGENESIS AND  
**2** DORMANCY IN EGGS OF EUROPEAN TETTIGONIIDAE (ORTHOPTERA)

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European species of the family Tettigoniidae have an annual or a biennial life cycle, due to differences in embryonic development. In a comparative study, using species with different life cycles, an attempt was made to find out the reasons for the differences in development time and to investigate how development is affected and controlled by environmental factors. Therefore, the eggs, deposited under various light-dark-cycles, were subjected to different regimes of temperature and moisture. The basic patterns of the course of embryonic development under the different conditions are described. During the embryogenesis of the Tettigoniidae there exists a dormancy sequence which in principle consists (1st) of an initial diapause occurring after blastoderm formation and the appearance of the embryonic primordium, and (2nd) of an embryonic diapause closer to the end of development, but which occurs not always in the same stage. Differences between species are mainly due to the rate of development under equal conditions and to the form of the initial diapause which may be either obligatory, facultative (and induced by low temperature or the photoperiod experienced maternally), or lacking at all, while the embryonic diapause is found in all species. The resulting life cycle strategies are discussed.

**R4.3.** ECLOSION RHYTHM OF THE SILKWORM, *BOMBYX MORI*  
**3**

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The silkworm moths show a characteristic eclosion rhythm which differs from other silkmooths. When the developing pupae were kept in certain photoperiodic regimen(e.g. LD 8:16), the moths showed overt bimodal eclosion rhythm with one peak in dark period, and with one peak at light-on. When the pupae were transferred from a synchronizing LD cycle to continuous darkness(DD), the eclosion of the dark period persisted with a free-running circadian rhythm, while the eclosion corresponding to the light-on peak was not shown. Vitamin A-deficiency, which brought about a loss of photoreceptive function in compound eyes, significantly reduced the light-on peak, but did not influence the timing of eclosion in the dark period. A transfer from DD or a photoperiodic regimen to continuous light(LL) produced a free-run rhythm with a period of ca. 18 hr. Light pulses in DD and dark pulses in LL were applied at different times to examine the oscillatory process. A model of the eclosion clock in the silkworm is proposed.

#### R4.3. EFFECTS OF JH AND ANTI-JH ON GROWTH AND DEVELOPMENT IN SEVERAL INSECT 4 PESTS

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Effects of JH and anti-JH on growth and development in several insect pests was studied especially in relation to diapause and phase variation.

Aestivation-diapause of the stem borer, Chilo partellus, can be induced by the treatment of JHA even under non-diapause condition like as larval diapause of C. suppressalis. The role of JH and other hormones in phase variation of the armyworms was studied. It was also found that JHA stimulated brachypterous form of the plant hopper, Laodelphax striatellus and the white-spotted tussock moth, Orgyia thyellina. Inhibition of metamorphosis by JHA was also discussed in some other species.

As for anti-JH, Precocene II caused precocious metamorphosis of the Oriental chinch bug, Cavelerius saccharivorus.

#### R4.3. CONTROL OF POLYOL METABOLISM AND DIAPAUSE DURATION OF 5 BOMBYX EGGS BY TEMPERATURE AND ANAEROBIOSIS

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Sorbitol utilization involved in the termination processes of embryonic diapause was not induced by a cold acclimation at a temperature as low as 1°C. In addition to such a low temperature treatment, an anaerobiosis of diapausing eggs with N<sub>2</sub> gas was effective to prevent sorbitol utilization and diapause termination even when the eggs were acclimated at 5°C for more than 100 days, which was enough to break down diapause in air. These results lead us to develop a new technique for long-term maintenance of silkworm eggs for more than one year.

**R4.3. RESULTS OF HYDROPRENE, METHOPRENE AND PRECOCENE-II TREATMENTS**  
**6 ON THE DIAPAUSING RICESTEM-BORER LARVAE**

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The diapausing pyralid (lepidoptera) larvae of Scirpophaga incertulas Wlk., Chilo auricilius (Dudgn.), C. polychrysus (Meyrick) and C. partellus (Swinh.), after the juvenoids hydroprene and methoprene, and antiallatotropin precocene-II application, underwent moulting and pupation or attained next morph, much earlier than the control and untreated larvae. The resultant forms were different kinds of intermediates. The response in shortening the duration of diapause was different in three treatments representing early, mid and late phases of diapause. Early phase treatment was most effective in terminating the diapause. There were morphogenetic and physiological derangements in the reproductive systems of the adultoids obtained from such treatments.

**R4.3. EFFECT OF LIGHT ON THE DEVELOPMENT OF THE ANGOUMOIS GRAIN**  
**7 MOTH, SITOTROGA CEREALELLA (OLIVIER).**

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The effect of light on the development of S. cerealella was studied. Three different light conditions, i.e., continuous light (LL), continuous darkness (DD) and the natural illumination (LD) were used. LL light regime stimulated rapid egg laying and hatching. Number of larvae that reached the adult stage under (LL) was less than under either LD or DD systems. The longevity of adults was longer than under LD and DD than those under LL regime. The average total numbers of eggs per female decreased significantly under LL regime. Both males and females resulted from breeding under LD regime were higher in weight than those produced at LL or DD.

**R4.3.**  
**8** PATTERNS OF PROTEIN SYNTHESIS IN THE LEFT COLLETERIAL GLAND OF  
PERIPLANETA AMERICANA DURING THE REPRODUCTIVE CYCLE.

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FRANK Y.T. SIN, Zoology Department, University of Canterbury, Christchurch,  
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A comparison is made between the wet weights, protein contents and protein synthesis in the left colleterial gland (LCG) at 14 time points of the reproductive cycle (4.5 days) of P. americana. The wet weight of the gland fluctuates throughout the cycle. The protein content also fluctuates with three cyclic changes. Only one of these changes can be correlated with ootheca synthesis. In vitro leucine incorporation into colleterial proteins is not uniform throughout the cycle. The highest incorporation coincides with the greatest increase in protein content of the gland and the greatest rate of oocyte growth. Electrophoretic analysis of the proteins extracted from the LCG reveals qualitative and quantitative changes. At least eight protein species are common to (a) the whole gland extract, (b) the artificially induced secretion, (c) the material collected in vivo from the genital vestibulum, and (d) the newly formed ootheca. All are synthesised in the gland. The protein species synthesised and their relative amounts vary during the cycle. The timing of synthesis and the lack of long term accumulation of some major colleterial proteins, in relation to ootheca synthesis, suggests that the LCG may be producing proteins for export as well as for synthesis of the egg-case.

**R4.3.**  
**9** NUCLEATORS AND COLD-HARDINESS IN INSECTS

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The influence of nucleators on the amount of supercooling of developmental stages in various insect species has been studied in the present paper. It is found that the quantity of nucleators in developmental stages of insects considerably influence the amount of supercooling. It seems that it is one of the reasons why most insects overwinter at non-feeding stages. Many insects overwintering at active stages are adapted to evacuate the gut content in the period before overwintering thus momentarily increasing the amount of supercooling for about 20°C. The insects which are unable to control the quantity of nucleators in their bodies while overwintering take refuge in leaf-litter or some other kind of shelter.

**R4.3.** TEMPERATURE DEPENDENT DEVELOPMENTAL  
**10** MODELS OF POIKILOTHERMS

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The possibilities, principles, and limitations of temperature dependent developmental models of poikilotherms are treated. The employing of these models in applied entomology is discussed. The SDR (sum of developmental rates) model is developed in "integral" form which negates the impact of "small Kaufmann effect". This model is presented in the form of FORTRAN IV computer program; after parametrization it may be used for any poikilotherm. A temperature input is realized by an original sine-wave algorithm, which makes possible to introduced time delay in the reaction of organisms to temperature changes.

**R4.4.**  
**1** EFFECTS OF SEED EXTRACTS OF AZADIRACHTA INDICA AFTER SYSTEMIC UPTAKE INTO BRASSICA OLERACEA ON FEEDING AND GROWTH OF PIERIS RAPAE AND P. BRASSICAE

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Regulation of food-intake behaviour and performance of two cabbage caterpillars, Pieris rapae and P. brassicae (Pieridae, Lep.) was studied as affected by Neem-seed kernel extracts (NSKE). The extracts were initially prepared in methanol; also other extraction solvents and procedures have been applied. Extracts could be systemically incorporated through uptake by excised leaves. Some results on uptake by intact plants will also be presented.

Leaf-consumption and development of first instars was registered. Time-course of food intake behaviour, food consumption, food utilisation parameters and growth were quantified for last instars. A neurophysiological analysis of sensory reactions of last instars to pure azadirachtin, NSKE-dilutions and sap of extract-infiltrated leaves has been exerted.

With first instars, development was retarded and mortality at first ecdysis occurred at 5 ppm NSKE. With last instars antifeedant effects were evident at 200-500 ppm NSKE. Significant effects on food utilisation and growth became apparent at 20 ppm. In the maxillary styloconic sensilla, only the deterrent receptorcell was excited by NSKE-solutions. Results were comparable for both species studies. Data on selection of individuals which during development showed higher levels of resistance will be presented.

R4.4.  
2

PATTERNS OF FOOD UTILIZATION AND EFFECTS OF  
TEMPERATURE IN EUPTEROTE MOLLIFERA (INSECTA: LEPIDOPTERA)

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4

Food utilization in E.mollifera was studied from hatching to the completion of final instar. In about 32 days a female or male larva consumed 1292 or 1133 mg leaf of Moringa pterygosperma, assimilated 726 or 655 mg and converted 176 or 135 mg. Assimilation efficiency of the larva decreased with the progress of growth. Assimilation and conversion ( $K_2$ ) efficiencies averaged to 43 and 29.5% for the entire feeding period. Differences in the rates of feeding, assimilation and conversion between males and females were not significant.

Studies undertaken on the effects of temperature (22, 27, 32 and 37°C) in the final instar male and female larva of E.mollifera have shown that food intake, growth and conversion efficiency have decreased with increase in temperature. The larval duration decreased from 12 days for the group reared at 22°C to 5 days for the group reared at 37°C.

R4.4.  
3 UPTAKE AND UTILISATION OF PROTEINS, PEPTIDES AND  
AMINO ACIDS BY APHIS FABAE

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In leaves of Vicia faba the infestation by Aphis fabae induces a degradation of specific proteins. The phloem sap of infested plants contains increased amounts of proteins, peptides and amino acids. Using artificial diets it could be shown that proteins and peptides are dissociated very fast by proteolytic enzymes mainly in the aphid intestine. The reaction products amino acids were found in the haemolymph and honey-dew and could compensate a lack of amino acids in the diet. Variations in the amino acid pattern strongly influence the efficiency of food utilisation, determined by measurement of food uptake or honeydew production in relation to aphid growth rate.

**R4.4.** PUPAL WEIGHT AS A MEASURE OF HOST PLANT SUITABILITY IN *YPONOMEUTA*  
**4** (LEPIDOPTERA; YPONOMEUTIDAE).

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The suitability of (host)plants as food for phytophagous lepidopterous larvae is often assessed by weighing pupae. In which way larval food consumption influences pupal weight is barely understood. Sensory stimuli perceived by taste receptors may regulate feeding behaviour. They alone being then responsible for the observed weights. On the other hand, differences in digestability among food plants may play an equally important role. In a broad study of the host plant relationships in the genus *Yponomeuta* pupal weight has proven to be an useful criterion. For the small ermine moth of orpine, *Y.vigintipunctatus*, it is found that pupal weight depends also on temperature and photoperiod during the larval phase. Because this relationship can only be detected when the duration of the larval life span is taken into account, differences in pupal weight seem to be caused primarily by an effect of external factors on feeding behaviour.

**R4.4.** THE ROLE OF TRACHEO-SPIRACULAR SYSTEM OF SOME COLEOPTERA  
**5** IN THERMAL ADJUSTMENTS.

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A comparative study of thermoregulation was made in some selected beetles from diverse taxonomic groups and habitats. Studies of insect respiration in terms of spiracular morphometry, spiracular regulatory adaptations, tracheal architecture reflect their importance in thermal adaptations. Temperature measurements at spiracular opening and deep inside the tracheal lumen have revealed significant results to prove that convective air circulation brings about thermal homeostasis. Concomitant studies on metabolism as reflected by oxygen consumption per unit weight have also revealed that aerial coleopterans have higher rates compared to nonflying beetles. In active as well as resting stage thoracic temperature was always found to be higher than the abdominal, where also segmental differences were noted. In aerial beetles this gradation was of a higher order than the terrestrial ones. Such  $T^{\circ}$  gradient seen in different body segments can be decisively explained on the basis of 'multicompartment' theory when supplementary evidence of extensive tracheal or air sacs supply in the region of high metabolic rate ( $\sim$  heat) is taken into consideration. These air sacs or 'ballooned trachae' not only act as buffers but also introduce fresh air to avoid lethal effects of high temperature.

R4.4.  
6

THE EFFECT OF HIND GUT OSMOLARITY ON  
THE URINE PRODUCTION OF P.TERRAENOVAE

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It was previously found that the Malpighian tubule's secretion rate of starved Protophormia terraenovae was higher than that of the controls under in-vitro conditions (Çotuk, in press). On the other hand, Cheung and Marshall (1973) had shown that the urine production decreases in starved Homopters in-vivo.

It is thought that the difference of the in-vitro and in-vivo techniques is responsible for the different observations obtained from these two experiments. In the case of this assumption is true, the hind gut may prevent the urine production in starved flies in-vivo.

For this reason, a Ringer droplet whose osmotic pressure was lowered by decreasing its sucrose concentration was placed to the cutting end of the Malpighian tubule from the hind gut. It was than observed that Malpighian tubule's secretion was decreased under this condition.

S4.1.  
1

CHITIN AND THE FINE STRUCTURE OF CUTICLES

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The chitin content of insect cuticles commonly falls within the range 20-50% (w/w, water-free basis) but may be as low as 1.4% or as high as 60.3%. Protein is the other major component. As determined by histochemical tests chitin is present only in the procuticle (i.e. exo- and endocuticles) but the tests may be unreliable when negative. Chitin is essentially a high molecular weight linear polymer of N-acetyl-D-glucosamine and occurs in cuticles as long microfibrils which, with their associated protein, are in a proteinaceous matrix. The fine structure of cuticles is discussed in terms of the deposition and organization of chitin microfibrils and their assembly into the lamellate structures seen in electron micrographs. The mechanical properties of cuticles depend to a large extent on the arrangement of the chitin microfibrils.



S4.1.  
2

## CHITIN-PROTEIN COMPLEXES AS ORDERED STRUCTURES

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X-ray diffraction and electron microscopy are being used to investigate the structures of ordered chitin-protein complexes from insect cuticles and other sources. A model for the complex in the ovipositor of the ichneumon fly *Megarhyssa* has been derived from the X-ray data. Chitin fibrils are arranged on a hexagonal lattice with center-to-center distance 7.25nm separated by a protein matrix. The latter consists of protein subunits arranged around each microfibril in a 6<sub>1</sub> helical array repeating in 3.1nm. Confirmation of this structure is obtained by image reconstruction of electron micrographs of stained sections. 6<sub>1</sub> helical arrays with the same repeat are found in many other complexes, such as *Sirex* ovipositor, *Aphrodite* chaetae, and *Loligo* pen, but significant differences occur in the fibrillar packing. Other complexes have been identified in which the protein axial repeats are 4.1 and 6.2nm, and preliminary analyses of these structures will be presented.

S4.1.  
3

## INTERFERENCE WITH CHITIN BIOSYNTHESIS IN INSECTS

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Chitin is an amino sugar biopolymer essential as a major structural component in arthropod cuticles. Since the disruption of chitin formation and deposition might be fatal, it has become a focus of intensive research aimed at finding new and selective compounds to control arthropod pests. The pathway of chitin biosynthesis involves many steps of which polymerization and fibrillogenesis are the most peculiar. Attempts to find disruptive chemicals should concentrate on these events. Fibrillogenesis is apparently a physico-chemical event which occurs at the cell surface and is poorly understood. More information has been accumulated regarding the polymerization step which is carried out by chitin synthetase, a membrane-bound enzyme. Most of the known chitin synthetase inhibitors act at this stage. The nucleoside peptide antibiotics (polyoxins, nikkomycins, neopolyoxins) resemble the structure of the chitin synthetase substrate and are powerful inhibitors which directly affect the enzyme. Other inhibitors acting directly on the polymerizing enzyme include various sulphenimides, phenyl carbamates and certain promising benzimidazoles. On the other hand insecticidal benzoylphenyl ureas which block chitin synthesis in whole animals and in intact tissues do not affect the cell-free chitin synthetase complex. Although their precise biochemical lesion is not known at present, it is apparently tightly associated with the chitin polymerization step.

#### 54.1. REGULATION OF CHITIN SYNTHESIS: MECHANISMS AND METHODS

4

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In the living insect, chitin synthesis follows the cuticle deposition cycle which in turn is regulated by fluctuating titers of the molting hormone(s). Thus, in last-instar cabbage worm larvae, chitin synthesis is highest immediately after molting and drops to approximately 20% by mid-instar and remains there until the succeeding instar. In organ cultures, chitin synthesis depends upon stimulation by molting hormone, either exogenous or endogenous, and is inhibited by diflubenzuron (DFB). This blockage is not overcome by additional molting hormone.

Chitin synthesis by cell-free extracts from insect tissues does not require, and is not stimulated by, exogenous molting hormone, nor is it inhibited by DFB. Thus the control mechanisms do not act on the hormone per se.

We have recently demonstrated that chitin is synthesized by established insect cell lines. Chitin synthesis by these cells does not require exogenous molting hormone but is inhibited by DFB. These findings indicate that the action of DFB is associated with the presence of an intact cell membrane. The stimulation of chitin synthesis by molting hormone appears to be a more complex process and may be associated with the synthesis of specific proteins which are normally absent in these cell lines.

#### 54.1. POTENTIAL OF BENZOYLPHENYL UREAS IN INTEGRATED PEST MANAGEMENT

5

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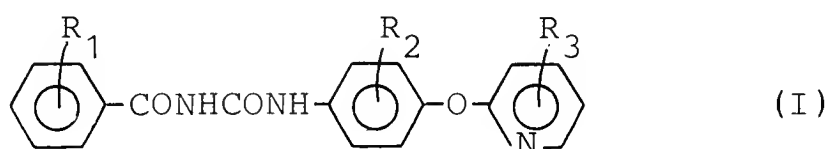
Integrated pest management (IPM) for insect control in agricultural systems requires the use of a variety of control tools in a mutually compatible manner. The insecticidal component of IPM is often difficult to choose because of chemical incompatibility with beneficial arthropods. Insecticide characteristics which mediate compatibility are residuality in the field, toxicity to target pests, and selectivity within the agroecosystem. Benzoylphenyl ureas have been tested in a number of cropping systems with regards to these characteristics. Tests with both target and non-target arthropods demonstrate the types of difficulties often encountered with choosing chemicals for IPM. Evaluations must include laboratory tests with beneficials and pests, several life stages, and several treatment methods as well as field tests. The use of life table techniques in which survivorship, generation time and fecundity are measured is especially appropriate for the benzoylphenyl ureas because of their delayed activity after treatments.

54.1.  
6

## STRUCTURE ACTIVITY RELATIONSHIPS OF BENZOYLPHENYL UREAS

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The structure-activity relationships for the larvicidal effects on *Spodoptera litura* have been studied on the series of the benzoyl-pyridyloxyphenyl-urea derivatives (I).



Substituents  $R_1$  on the benzoyl ring have the crucial influences on the insecticidal activity. Among substituents  $R_3$  on the pyridine ring, lipophilic groups with larger positive  $\pi$  constants seem to enhance the activity.

Advantages of the introduction of pyridyloxy group will be summarized in comparison with other series of benzoyl-phenyl-urea derivatives.

54.1.  
7

## MODE OF ACTION AND INSECTICIDAL PROPERTIES OF DIFLUBENZURON

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After a brief introduction into the field of the insecticidal benzoylphenyl-ureas, this paper will mainly concentrate on the mode of action and insecticidal properties of diflubenzuron (dfb). Attention will be paid to histological phenomena in tissues from treated insects. Furthermore the main hypotheses about the mode of action will be discussed.

Some factors influencing the ovicidal and larvicidal activities of dfb as the developmental stage and the feeding habits of the insects, the environmental conditions and the formulation of the compound will receive attention. Dfb can also affect postmoult hardening of the adult cuticle. Some of the possible consequences will be discussed, like a decreased ability for locomotion, flight, copulation, and a reduced fecundity.

After a few remarks about the selectivity of dfb, some of its insecticidal and acaricidal properties will be briefly summarized.

## 54.1. CONTROL OF INSECTS WITH BENZOYLPHENYL UREAS

8

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The benzoylphenyl ureas are characterized as insect growth regulators because of their activity against insects that is expressed in different behavioral or physiological systems, i.e., disruption of metamorphosis, antifeedant activity, delayed mortality, and ovicidal activity. The inhibition of chitin synthesis as the mechanism of action of the benzoylphenyl ureas would indicate that a broad spectrum of activity is expected with these chemicals. However, a narrow spectrum of activity actually exists in the identification of pest control strategies. The successful utilization of these chemicals in actual programs is directed towards the maximum likelihood of exposure either by per os or contact, to periods of susceptibility within the biology of the species, and recognition of delayed activity. The insecticidal activity of the benzoylphenyl urea analogues is present against important economic insects of forests, crops, human, and livestock and information as to-date indicate that they may become an important integral part in our pest management control strategies.

## 54.2. ENDOCRINE APPROACHES TO THE STUDY OF THE METAMORPHOSIS OF THE INSECT NERVOUS SYSTEM

1

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During metamorphosis the central nervous system (CNS) undergoes profound changes to accomodate the transition from the larva to the adult. We have studied the alterations in the abdominal nervous system of the moth Manduca sexta. The transition from the larva to the adult is accompanied by the programmed death of approximately 50% of the larval neurons. Some cells die soon after pupal ecdysis as certain elements in the larval nervous system are dismantled. The remainder persist through metamorphosis to mediate ongoing pupal behavior but then die after adult ecdysis. The remaining larval neurons undergo a redifferentiation during which new dendritic fields and new adult connections are made. A small percentage ( about 20%) of neurons in the adult abdominal CNS are new. Neuroblasts in the segmental ganglia produce embryonic cells during larval life, some of which then differentiate into new adult-specific neurons during metamorphosis.

The process of CNS metamorphosis is under rigid endocrine control. Neuronal differentiation and cell death are linked to the changing titers of ecdysteroids in the absence of juvenile hormone. The metamorphosing CNS also shows abrupt functional changes caused by eclosion hormone.

S4.2.  
2

## RECENT ADVANCES IN GRASSHOPPER DEVELOPMENTAL NEUROBIOLOGY

HAIG KESHISHIAN    The University of Chicago, USA.

Recent advances in grasshopper embryology have made it possible to examine the development of uniquely identifiable neurons in both the CNS and the periphery. Among the problems addressed have been the acquisition of specific cellular phenotypes, the morphogenesis of individual neurons, the establishment of both central and peripheral axonal projections, and aspects of synapse formation, including target acquisition and neurotransmitter development.

Two areas of research which have been especially fruitful will be presented: 1) the role of positional cell determination in establishing peripheral nerve trajectories, and 2) the commitment within cell lineages of neurons to specific neuronal phenotypes, notably in the expression of neurotransmitter substances.

S4.2.  
3

## INSECT NEUROPEPTIDES

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Neuropeptides function in insects as in other organisms as both circulating hormones and as locally acting neurotransmitters. The same peptide may function in both modes. Evidence is increasing for a role for peptide transmitters in skeletal neuromuscular transmission. The neuromuscular junction may therefore provide a convenient and accessible preparation for analyzing the sub-cellular mechanisms of peptide action.

In this talk I will review recent advances in the study of the structure and function of insect neuropeptides. In particular I will emphasize the importance of molecular biological and immunochemical approaches in the study of structure and the importance of establishing 'model' cellular systems for the study of function.

54.2.  
4

## FUNCTIONAL MORPHOLOGY OF NEURONAL CIRCUITS

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In flies, a variety of neuroanatomical methods have been used to elucidate the organization of descending neurons (DNs) leading from sensory centers in the brain to motor centers in the thoracic ganglia. Fills of single DNs with Lucifer yellow and of assemblies of DNs with cobalt show that generally DN dendrites are organized as uniquely identifiable clusters in the brain. Neurons of a cluster have similar dendritic trees sharing the same or highly similar inputs, as demonstrated by cobalt coupling between one class of interneuron and several DNs. A similar situation is found in the thoracic ganglia: bundles of DN axons make common connections onto clusters of cobalt-coupled interneurons and motor neurons, the former being arranged segmentally and corresponding in position to anterior and posterior divisions of embryonic neuromeres. Electron microscopy of marked DNs has resolved some of their functional connections, particularly in cobalt-coupled pathways. Although there are neurons that structurally meet criteria for "uniquely identifiable command neurons," the anatomical data suggest that motor activity is controlled by cooperative interaction between many DNs and local interneurons with similar forms and dispositions.

4

54.2.  
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## NEUROSPECIFICITY IN THE INSECT NERVOUS SYSTEM

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The growth of insect sensory neurons has been studied anatomically, using methods which stain individual neurons. These anatomical techniques have demonstrated that two forces control the growth of the axonal arborizations of sensory neurons. The first is peripheral position of the cell body. Position of the cell body at the time a sensory neuron goes through its terminal mitoses determines the location of the axonal arbor in the Central Nervous System. This was demonstrated by transplantation of sensory neurons. The second is competition. This was demonstrated by destroying some cells and showing that the remaining ones expand their axonal arborization in the deprived region. These two forces determine the location and strength of synaptic connections through their influence on axonal arbor shape and location.

## 54.2. ANALYSIS OF NEURAL CIRCUITRY IN THE LOCUST FLIGHT SYSTEM 7

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Insect flight consists of a rhythmic motor program, which is produced by interactions between sensory information and central rhythm generating circuits. In the CNS of the locust, intracellular recording and staining techniques have made a cellular analysis of these interactions possible. Recent studies in several laboratories show that interneuron networks play a major role in both the generation and the modulation of flight motor activity. We have concentrated on a set of thoracic premotor interneurons which directly drive the flight motoneurons. These premotor neurons are the site of convergence of descending sensory information responsible for correctional steering and of the centrally generated flight rhythm.

## 54.2. PROGRESS IN RECENT CELLULAR NEUROBIOLOGY OF INSECTS 8

HUBER Franz

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Morphological and physiological identification of neurons within the CNS of insects offers a way to analyse single neuron and circuit features for the generation of motor programs and the evaluation of behaviorally relevant signals. The progress will be outlined by taking sound communication of crickets as an example. Furthermore, new fields of interest will be discussed.

54.3.  
2

THE ROLE OF ECDYSTERONE IN THE DEVELOPMENT OF THE ACCESSORY  
GLANDS OF TENEBRIO MOLITOR (COLEOPTERA).

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A major ecdysteroid peak occurs at the mid-pupal stage of mealworms (Becque et al., 1978, Develop. Biol. 64:11). Coincident with that peak, there is a bout of mitotic activity in the male accessory reproductive glands and also a commitment toward the adult phenotype. Both the bean shaped accessory glands (BAGs) and the tubular accessory glands (TAGs) are mesodermal derivatives. When young pupal glands are cultured in vitro, ecdysteroid stimulate mitotic activity. From cytophotometric and autoradiographic analyses, and from DNA-fluorescence patterns measured in a cell sorter, the durations of the phases of the cell cycle have been calculated. Such data have been compared between cultures in vitro, with and without ecdysterone, and with the glands developing in situ. Preliminary evidence suggests that ecdysterone shortens G<sub>2</sub> and lengthens G<sub>1</sub> in the cell cycles of the secretory epithelium of the TAGs and BAGs.

During terminal differentiation of the BAGs and the TAGs, each produces a defined set of secretory proteins. The onset of the synthesis of these differentiation-specific proteins, as detected by immunochemistry and by changing patterns of leucine incorporation, follows, shortly after the ecdysterone-stimulated cell division in the mid pupa. The inter-relationships of cell division, the ecdysteroid peak, and developmental commitment will be discussed.

54.3.  
3

PREDICTIONS OF SIZE AND FUNCTION OF SPERMATOPHORES

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ROCKY MTN. BIO. LAB., CRESTED BUTTE, COLORADO 81224      USA

During mating, male Lepidoptera pass accessory gland products into the female's bursa. These products harden to form a spermatophore. Lepidopteran spermatophores have been shown to serve at least two functions: first, supplying nutrients to the female, and second, stimulating mate rejection behavior. This report focuses on the nutritional aspects of spermatophores in species with differing importance of the spermatophore in mating prevention. Predictions are examined concerning the importance of male nutrient donation in the context of the female's overall resource budget for species with differing life histories and modes of protection of female mates by males.

4



S4.3.

4

#### NUTRIENT TRANSFER IN COCKROACHES

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The nutritional resources required for reproduction in German cockroaches is substantial. Females reared on dog food invest 26% of the nitrogen reserves, and 34% of the dry weight reserves, available to them at oviposition, into their oothecae. The quality of diet affects the rate of oothecal production. Females maintained on a dog food diet (24% protein) produce an ootheca in about 14 days post-ecdysis, whereas those on a low protein diet (5% protein) produce an ootheca in about 42 days post-ecdysis. It has been found that urates as well as vitellins are incorporated in oothecae and the urates apparently are metabolized during embryogenesis. Radiotracer studies, using dual-label technology, have indicated that both  $^{14}\text{C}$ -urates and  $^3\text{H}$ -leucine injected into females are found in relatively high levels in their oothecae. In addition, injection of these materials into males followed by mating with females results in the production of oothecae which contain both  $^{14}\text{C}$ -urate and  $^3\text{H}$ -leucine (radiolabel). Those females maintained on low protein diets prior to mating incorporate significantly more radiolabel into their oothecae than do those on dog food.

S4.3.

5

#### CONTROL OF DROSOPHILA FEMALE REPRODUCTIVE BEHAVIOR BY AN ENZYME SYNTHESIZED IN THE MALE REPRODUCTIVE TRACT

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Drosophila melanogaster males transfer to females as a component of the seminal fluid a carboxylesterase (esterase 6, EST 6). This enzyme in conjunction with other compounds also present in the seminal fluid has effects on sperm utilization, female fertility, and the timing of female remating. EST 6 is synthesized in the male anterior ejaculatory duct possibly under the influence of juvenile hormone. A possible in vivo substrate for EST 6 is cis-vaccenyl acetate (cVA), a pheromone-like compound, also produced by the male and transferred to females at mating. Purified EST 6 is capable of hydrolyzing cVA to its alcohol which acts as an antiaphrodisiac pheromone in laboratory tests.

### 54.3. FUNCTIONS OF ACCESSORY GLANDS IN FEMALE INSECTS

6

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Secretions of the accessory reproductive glands of female insects are typically used to provide protection for the eggs at the oviposition site. With many insects, the production of the accessory secretion represents a considerable metabolic investment which otherwise could be directed towards the production of additional progeny. Thus, it is not surprising to observe that in higher orders the accessory glands are often either reduced, absent or modified to include other functions ancillary to the reproductive process. The milk gland of ovoviviparous dipterans and the poison glands of stinging hymenopterans are conspicuous examples of accessory reproductive gland modification.

In Musca domestica and in certain other muscid and calliphorid flies thus far examined, the accessory gland secretion facilitates the fertilization of eggs. Fertilization in Musca is a complex process whereby secretions of the accessory gland and the egg micropyle interact with sperm to aid its entry into the egg. An overview of the function of female accessory glands with special emphasis on aspects of the sperm-egg confrontation and its correlation with other animal systems will be presented.

### 54.3. ROLE OF JUVENILE HORMONE IN THE FIRST AND SECOND GONOTROPHIC CYCLES OF CULEX PIPIENS

7

Roger Meola  
Texas A&M University

Juvenile hormone initiates several events necessary for gonotrophic development in Culex pipiens mosquitoes including the behavioral patterns responsible for blood hunger and biting behavior. Evidence for the role of juvenile hormone on the induction of biting after emergence is reviewed along with the results of recent studies on the action of juvenile hormone in blood-fed mosquitoes.

The results of allatectomy experiments with blood-fed mosquitoes showed that biting behavior is regulated by the cyclic production of juvenile hormone. During yolk deposition, biting is suppressed by the absence of juvenile hormone. However, once egg maturation is completed, the corpora allata resume the secretion of juvenile hormone and initiate the second biting cycle. Since blood feeding is suppressed when gravid females are forced to retain eggs, evidently a two-phase process is necessary to initiate a second biting cycle; juvenile hormone secretion after egg maturation and oviposition of the first batch of eggs.

**54.3.** OVARIAN INHIBITION OF JUVENILE HORMONE SYNTHESIS IN DIPLOPTERA  
**8** PUNCTATA

BARBARA STAY AND SUSAN M. RANKIN

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The mature ovary was shown to inhibit synthesis of juvenile hormone (JH) by the corpora allata (CA) by experimental manipulations of the ovary and subsequent radiochemical assay of rates of JH synthesis. When ovaries were removed prior to complete maturation, rates of JH synthesis declined but more slowly than normal. The decline in rate of synthesis was delayed further when active CA replaced the inactive CA of an ovariectomized host. By combining a stimulatory and putatively inhibitory ovary in the same host we demonstrated that the mature ovary not only ceased to stimulate but actively inhibited rates of JH synthesis.

**54.3.** HIERARCHAL LEVELS OF HORMONAL CONTROL OF VITELLOGENESIS IN LOCUSTS  
**9**

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At the highest level of hierarchy, three hormonal fractions from the locust brain have been examined and isolated by HPLC. The first of these, allatotropin, indirectly affects vitellogenesis by controlling the synthesis of juvenile hormone (JH) in the corpora allata (CA). Allatotropin is present in the brain and corpora cardiaca (CC) of newly emerged and of vitellogenic females at comparable levels. JH synthesis is dependent on temporal development of responsiveness of the CA to allatotropin. At a lower level of hierarchy, two distinct protein inhibiting factors (PIF) directly control protein synthesis in the fat body. Inhibition is dose-dependent and PIF can be extracted from the hemolymph at the end of the first vitellogenic cycle. Adipokinetic hormones I and II from the glandular lobes of the CC are minor factors in short-term attenuation of protein synthesis by the fat body.

§4.3. HIGH AND LOW MOLECULAR WEIGHT VITELLOGENINS, EXOGENOUS AND  
10 ENDOGENOUS VITELLOGENIN SYNTHESIS

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In some insect species only yolk polypeptides of low molecular weight (MW of about 50,000 daltons) are found. In some other species only yolk polypeptides of high molecular weight (over 100,000 daltons) have been described while in still other species a combination of both classes occurs. This suggests that, perhaps, in the common ancestor of insects two classes of vitellogenins were present which were maybe controlled by different hormones or hormonal balances. In the course of Evolution mutations may have occurred in some species leading to the differential disappearance of one of the classes. This could partially explain the differences observed in hormonal control of vitellogenins among different insect species. It should not be overlooked that besides extraovarian synthesis of vitellogenin in the fat body, the ovary itself may be an important site of synthesis as already been shown in *Drosophila*, *Bombyx*, *Sarcophaga* and *Leptinotarsa*. Exogenous and endogenous vitellogenin synthesis might also be under different endocrine control.

§4.3. ALLATOTROPIC HORMONE IN FEMALE LOCUSTA MIGRATORIA AND ITS  
11 EFFECTS ON CORPUS ALLATUM ACTIVITY AND VITELLOGENESIS

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In female Locusta migratoria, JH-III controls vitellogenesis. CA-activity is regulated by the brain. There is evidence, that the activating principle is a humoral factor from the median neurosecretory cells. By microsurgical methods (section of the NCC I), release of the neurosecretory material from the brain can be prevented. The CA are inactivated and vitellogenesis does not take place. Injection of corpus cardiacum homogenate from vitellogenic females, and JH-III injection can restore vitellogenesis. CA activity was examined by histological methods and by CA in vitro-assay. Vitellogenesis was followed by total haemolymph protein titre, SDS gel electrophoresis and vitellogenin titre measurements. From our data we postulate the following sequence for the action of an allatotropic hormone:



**S4.3.** THE INFLUENCE OF LARVAL AND ADULT FEEDING ON REPRODUCTION  
**12** IN SPODOPTERA EXEMPTA (LEPIDOPTERA:NOCTUIDAE)

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The most important factor determining the fecundity of S. exempta was the availability of water to the adult moth. If water was not available then most moths died without laying even if they had unrestricted access to food at the larval stage. When moths had free access to water the only factor limiting fecundity was the weight of the moths themselves and this was influenced by feeding conditions at the larval stage. Feeding the moths sucrose, amino acids or protein had no effect on the preoviposition period or fecundity although sucrose did increase the longevity by several days. The importance of these results in relation to moth migration and the utilisation of food reserves will be discussed.

**S4.3.** PHYSIOLOGY OF NITROGEN EXCRETION IN BLOOD-FED AEDES AEGYPTI  
**13**

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Female mosquitoes ingest more blood protein than they require for oogenesis, and since no nitrogen reserves are stored, each gonotrophic cycle is accompanied by considerable nitrogen excretion. Besides uric acid, the major nitrogenous constituent, almost half of the excessive nitrogen is excreted in other forms: urea, ammonia, protein (digestive enzymes), and amino acids. The detection of significant amounts of urea and ammonia was surprising because of the typically terrestrial biology of adult mosquitoes.

The temporal excretion pattern of the nitrogen components is marked by 2 main peaks: uric acid plus urea and ammonia appear between 4 and 28 hours after blood meal. Evidently, uricotelic and ureotelic pathways are operating simultaneously. The proteinaceous nitrogen appears together with the bulk of hematin between 28 and 40 hours after blood meal. This part of the excretion, which may be called defecation seems to be under a neural control.

The extent of urea versus uric acid production can be manipulated to some extent by supplying or depriving oogenic females of water; the absence of dietary water forces nitrogen catabolism towards the more costly synthesis of uric acid. Energetic implications of this laboratory finding on the ecology of free-living mosquitoes remain to be elucidated.

**S4.3.** THE REPRODUCTIVE CYCLE OF PARCOBLATTA FULVESCENS FEMALES  
**14** AND ITS RELATIONSHIP TO URATE EXCRETION

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Under controlled laboratory conditions, adult females of the woods cockroach, P. fulvescens, produce an ootheca approximately every 7 days. During the first 4 days of the cycle they feed and drink vigorously, but feeding and drinking decline to a low level for the last 3 days. The ootheca is carried by the female for 1-2 days after which it is dropped. The cycle is then repeated. The amount of urate excreted as formed urate-containing pellets during this cycle is variable depending upon the amount of nitrogen present in the diet. On a 4% nitrogen diet only trace amounts of urate are excreted. As dietary nitrogen is increased to 6.7%, a substantial number of urate-containing pellets are voided in a cyclic manner with a peak occurring at days 2-4 of the reproductive cycle. On the basis of this and other evidence it appears that urate voiding by this unusual means may serve as a mechanism for regulating body-nitrogen levels. Most cockroach species examined to date lack this capability.

**S4.3.** HORMONAL CONTROL OF THE PROTEIN SYNTHESIS BY THE ACCESSORY  
**15** REPRODUCTIVE GLANDS OF LEPTINOTARSA DECEMLINEATA

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The accessory reproductive glands (ARG's) of the male Colorado beetle secrete about 50 polypeptides with molecular weights varying between 15,000 and 650,000 Dalton. Most of these polypeptides are synthesized by the gland itself.

Injection of 2 ng ecdysterone stimulates protein synthesis in the ARG's. This enhanced synthesis mainly involves the synthesis of secretory proteins. Ecdysterone also stimulates *in vitro* protein synthesis by the ARG's.

Animals starved for 24 hours show a strongly reduced JH III titer and a significant reduction of protein content and protein synthesis by the ARG's. However, application of JH III did not stimulate protein synthesis in these glands.

ARG's of unmated males contain large amounts of secretory proteins, but the protein synthesis is very low.

#### S4.3. IN VITRO MAINTENANCE OF THE HOUSE CRICKET

16 (Acheta domesticus) TESTIS

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The insect testis has been studied in vitro using isolated germ cells and in a few instances in the intact form. Most demonstrations of germ cell development in vitro are essentially continuations of processes already underway in the intact testis. The in vitro maintenance of the testis of Acheta domesticus (Orthoptera) was attempted. Oxygen consumption measurements of the testis showed it could easily be maintained alive for up to 48 hours in Grace's insect tissue culture medium. Addition of ecdysone, 20-OH ecdysone and/or juvenile hormone III in normal and supra-physiological amounts failed to elicit developmental response in germ cells, even with macromolecular factor containing supplements in the media. However, under the light microscope stages intermediate between late spermatid and sperm were observed. These stages have not been noted in the literature and descriptions are presented.

#### S4.3. HISTOCHEMICAL EFFECT OF BISAZIR AND TRIPHENYL TIN CHLORIDE ON CARBOHYDRATE, PROTEIN AND LIPID CONTENT OF TESTIS IN PERIPLANETA AMERICANA L.

17

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Various histochemical tests of normal and treated insects were performed in order to understand the effect of bisazir and triphenyl tin chloride on carbohydrate, protein and lipid content in testis of P. americana L. The normal testis was found to contain neutral hetero polysaccharides (NHPS) and other protein carbohydrate complex material in the capsule and sperm cells; and acid mucopolysaccharides (AMPS) in primary, secondary spermatogonia and spermatids. However, slight depletion of AMPS and NHPS were observed after 7 days of treatment with chemosterilants. The primary and secondary spermatogonial cells of normal testis were found to contain glycogen, however, increase in accumulation of glycogen was observed just after 4 days of treatment. The primary and secondary spermatogonial cells, spermatids and sperm cells were found to contain tyrosine containing protein and general protein in normal testis, while increase in the concentration of protein was observed after 4 and 12 days of treatment with chemosterilants. The testis after 4 days of treatment denoted increase in the lipid content, however, such concentration of lipid content was found nearly to normal after 12 days of treatment.

**54.3.** ELECTRICAL POTENTIAL DIFFERENCES IN THE MEROISTIC OVARY OF  
**18** *SARCOPHAGA BULLATA* : AN ELECTROPHYSIOLOGICAL APPROACH

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In *Sarcophaga bullata*, the oocyte is connected to 15 trophocytes by means of cytoplasmatic bridges, also called ring channels. The layer of follicle cells covering the trophocytes consists of tightly interconnected cells through which no haemolymph proteins pass. The follicle cells around the oocyte are not tightly packed. Electrophysiological measurements showed that an electrical potential exists between the oocyte and the trophocytes. At the onset of vitellogenesis ; this potential difference is  $8.7 \pm 3.1$  mV, the oocyte being at positive potential. When yolk deposition comes to a stop, this potential difference drops to  $4.3 \pm 2.7$  mV. Acetylstrophantidin, an inhibitor of  $(Na^+ + K^+)$ -ATPase, influences the membrane potential of both trophocytes and oocyte but it does not significantly alter the potential difference between trophocytes and oocyte. The influence of the changes in extracellular  $K^+$ -concentration on membrane potentials has been investigated.

**54.3.** UNEQUAL DISTRIBUTION OF HAEMOLYMPH PROTEINS IN THE OOCYTES  
**19** OF *SARCOPHAGA BULLATA* AND *LEPTINOTARSA DECEMLINEATA*

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By means of immunocytochemical methods, we found that in the polytrophic ovary of *Sarcophaga bullata*, vitellogenin enters the oocyte at all sites where the haemolymph proteins can reach the oolemma. However, when the follicles grow and become more tightly packed within the ovary, vitellogenin incorporation is reduced at the sites where the follicles contact each other. The lipoprotein is not taken up by the oocyte during early vitellogenesis. From mid vitellogenesis on, it is found distributed in the periphery of the oocyte and in patches throughout the central ooplasm. Oocytes of the telotrophic ovary of *Leptinotarsa decemlineata* accumulate 3 haemolymph proteins, vitellogenin 1, vitellogenin 2 and lipoprotein. The uptake of proteins is more intense at the distal part of the oocyte. Lipoprotein is detected in very small granules in the oocyte, close to the follicle cells. In the central part of the oocyte it is localised in large yolk granules. The uptake of vitellogenin 2 starts earlier than that of vitellogenin 1.



**S4.3.** OOCYTE DIFFERENTIATION AND OVIPOSITION PREFERENCE OF THE  
**20** RICE WEEVIL, SITOPHILUS ORYZAE (L.) (COLEOPTERA : CURCULIONIDAE)

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The telotrophic ovaries of the adult rice weevil, Sitophilus oryzae contain nurse cells distinctive to three zones of the tropharium. The nurse cells of the proximal part provide glycogen and lipid material and those of the next two zones synthesise nucleic acids and protein. The last zone is further characterised by the presence of prefollicular cells, oocytes and intercellular bridges between the germ cells and the nurse cells. The nutritive cords are discernible in the adult until the seventh day. Development of the oocyte can be phased out into seven stages, three of which are vitellogenic. The cytochemical and autoradiographic studies suggest besides autonomous proteid yolk synthesis by the oocyte itself, the follicular and extraovarian contributions exert influence on the gradual development of the oocyte.

The ecophysiological observation, further, reveals the size, temperature and moisture of the grains are important factors for oviposition and adult emergence irrespective of varieties, texture and chemical constituents of the grains.

**S4.3.** STERILIZING EFFECTS INDUCED BY PRECOCENES ON  
**21** *Blattella germanica* (L.)

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Sterilizing effects induced by Precocene 1, Precocene 2, Ethoxyprecocene 2 and 3,4-Dihydroprecocene 2 (3,4-DHP2) on *Blattella germanica* (L.) (Dyctioptera, Blattellidae), have been studied.

Compounds were applied topically at doses of 200, 100 and 50 µg on newly emerged adult females, and the corresponding activity was controled by measuring the length of the last oocyte and the total protein content of colleterial glands, 7 days after the treatment. Structural studies of *corpora allata*(CA) of treated and untreated specimens were also performed.

Since all compounds, including 3,4-DHP2, have shown an important degree of inhibitory activity at doses of 200 µg, the results have been discussed in terms of discrimination between degenerative effect at CA level and unespecific toxicity.

54.3. IS IN VITRO CA-ACTIVITY A PROBE FOR JH-TITRES IN VIVO?  
22

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In female Locusta migratoria, the haemolymph JH-III-titres were measured daily from eclosion until oviposition by use of the GC-MS-MIS technique. Simultaneously, the CA-activity was monitored using the in vitro radiochemical assay. The amount of JH-III secreted into the medium was determined and the ratio  $^{14}\text{C}/\text{JH-III}$  was followed. After a primary lag phase which is due to equilibration of endogeneous methionine pools, the ratios are fairly constant. In immature females, in vitro CA-activities were rather low which corresponds well with the small amounts of JH-III present in the haemolymph. In mature females, the JH-titre and the CA-activity vary considerably in the different individuals. In general, JH-III in the haemolymph of mature females was significantly higher than in the immature. The correlation of JH-release in vivo and CA-activity in vitro will be discussed.

54.3. A ROLE FOR THE OVIDUCAL NERVES IN EGG-LAYING IN THE LOCUST,  
23 LOCUSTA MIGRATORIA

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A pair of oviducal nerves innervate the lower lateral oviducts and the most anterior portion of the common oviduct in the reproductive system of Locusta. The electrical activity within these nerves showed a recurrent bursting pattern in females which had been interrupted in the process of egg-laying and this patterning was not evident in non-egg-laying females. This nervous activity was associated with contractions of the muscles in the immediate vicinity of the innervation. Implanting electrodes around these nerves in free-walking preparations demonstrated a lack of electrical activity during egg-laying and an increase in electrical activity in females interrupted while egg-laying.

The significance of this phenomena in the physiology of egg-laying will be discussed.

#### 54.4.

1

#### APHID POLYMORPHISM: AN ECOLOGICAL PERSPECTIVE

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Aphids have complicated life cycles made up of a sequence of short lived morphs each of which is well adapted to living on its host plant at a particular time of the year. Two factors have been particularly important in the evolution of these life cycles: programmed anticipation of the seasonal trends in habitat quality and the ability to use environmental cues to synchronize their development with critical stages in the development of their host plant, such as bud burst and leaf fall. This will be illustrated by reference to the seasonal variation in reproductive biology and the timing of sex in aphids.

#### 54.4.

2

#### FACTORS INVOLVED IN THE PRODUCTION OF WINGED AND WINGLESS APHIDS

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The majority of present aphid species live in climates with great seasonal oscillations. Many of them show host alternation and need winged forms to recolonize the primary host in autumn. Factors inducing this migration are usually predictable environmental factors such as photoperiod and temperature. On secondary hosts the survival strategy includes dispersal, governed by less predictable factors like population density, activity of natural enemies and physiology of the host plant. The relationship between host plant quality and wing dimorphism is complex: a generalistic aphid like *Myzus persicae* can easily produce winged morphs when its populations grow vigorously due to optimal nutrition. The crowding effect, however, can be suppressed by specific host factors, sometimes token stimuli, resulting in aptera production.

Specialistic aphids also disperse, but to the same or a related host species. Their reaction to the physiology of the host is often peculiar: *Chaetosiphon fragaefolii* will produce winged individuals when conditions for growth are optimal, but without the need of a crowding stimulus. What is the adaptive value of wing dimorphism; Do aphids anticipate a change in their environment and what are the inducing signals? These questions are discussed in the light of our current knowledge of specific host factors influencing the course of development in generalists and specialists.

54.4.3 PHYSIOLOGICAL ASPECTS IN THE DETERMINATION OF  
3 PARTHENOGENETIC AND SEXUAL FEMALES

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Photoperiod is the environmental cue usually associated with the induction of the parthenogenetic and sexual morphs. Parthenogenetic females (viviparae) exposed to long days give birth to viviparae while those subjected to short days produce sexual females (oviparae). Topical application of juvenile hormone (JH) can mimic long days by inducing the production of viviparae under short-day conditions. On the other hand, the effect of precocene III (an anti-JH compound) mimics short days by inducing oviparae in long days. Although the titres of JH III are low in adults, they are two or three times higher in long-day than in short-day-reared aphids. The photoperiodic receptor mechanism is located in the brain and may be situated in regions of the pars intercerebralis lateral to a prominent group of neurosecretory cells. These Group 1 cells are also necessary for a photoperiodic response. Recent evidence suggests that the effect of these brain regions on the morph of the progeny may be mediated via the corpus allatum. It is possible that JH controls both metamorphosis and photoperiodically regulated polymorphism in aphids.

54.4.4 INDUCTION BY PRECOCENE OF ALATA PRODUCTION BY APHIDS  
4

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The precocenes can be used to investigate the role of juvenile hormone in aphid morph determination because they are known to interfere with corpora allata functioning. Precocene II has a strong alatizing effect on the progeny of treated virginoparae of the potato aphid, Macrosiphum euphorbiae. The mechanism by which precocene II produces this effect is not clearly related to interfering with JH production as indicated by the results of rescue experiments with JH applications. Further work examining the effects of precocene and JH treatments on aphids will be presented and discussed in relation to current hypotheses concerning the physiological control of aphid wing determination.

**54.4.**  
**5** SUPERNUMERARY LARVAL INSTARS AND PRECOCIOUS METAMORPHOSIS  
IN APHIDS INDUCED BY PRECOCENE, IN RELATION TO PHOTOPERIOD

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6-Methoxy-7-ethoxy-2,2-dimethylchromene (PrIII) causes maternally-treated Myzus persicae larvae to metamorphose precociously into 3rd- or 4th-instar adultoids (Hales & Mittler, 1981). This is so, in apteriform and alatiform virginoparae and in males if these aphids are exposed prior to birth and maternal PrIII treatment to short-night (16hL:8hD) but not in female morphs prenatally exposed to long-night (LN) (9hL:15D), and in males at either regime. Presumably the corpora allata (c.a.) of females exposed to LN are less active and not destroyed by PrIII, and c.a. activity of males is not reduced at LN. Simultaneously to producing larvae that develop precociously, PrIII-treated aphids produce larvae that undergo 5 molts. Supernumerary 5th-instar larvae are produced that molt either successfully into 6th-instar adults if apteriform or incompletely when alatiform. Prenatal LN also cancels this response. Supernumerary male larvae have not been observed. This suggests that PrIII causes either destruction of the c.a. (Hales & Mittler, 1981) and reduction in JH level (in the 2nd or 3rd instar) or stimulation of the c.a. and increase in JH level (in the 4th instar) so that an additional larval instar develops. The responses to PrIII of M. persicae therefore provide an indication of c.a. activity in these aphids.

**54.4.**  
**6** HORMONAL REGULATION OF SEX DETERMINATION IN APHIDS

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Treatment of adult aphids (Myzus persicae) with precocene brings about precocious metamorphosis of the first offspring born after treatment and, later, the production of male offspring. It is proposed that male determination occurs in response to subthreshold concentrations of juvenile hormone (JH). The Myzus persicae (G<sub>0</sub>) treated with precocene give birth to only a few male offspring late in reproductive life, but their daughters (G<sub>1</sub>) give birth to male and female offspring in various temporal patterns. Two possible mechanisms are discussed. In the first, the patterns are explained by an indirect effect of JH, and are generated by a putative peptide hormone transported intraneuronally to the ovaries and acting on pre-growth stage oocytes. In the second mechanism, the observations are explained simply in terms of fluctuations in the level of circulating JH, which directly influence X-chromosome behaviour at or just before the (mitotic) maturation division of the oocyte, females being XX and males XO in aphids. Experiments designed to provide evidence in favour of or against these two models are described. The system is of particular interest in that it provides the first example of a hormonal influence on chromosome behaviour resulting in sex determination.

54.4.  
7

#### BIOTYPES AND CHROMOSOMAL POLYMORPHISM IN APHIDS

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Aphids show an unusually high degree of chromosomal polymorphism (Blackman, 1980), possibly related to the fact that they : 1) have holocentric chromosomes, 2) undergo thelytokous reproduction that is either continuous (anholocyclic) or interrupted by an annual sexual generation (holocyclic). Chromosomal rearrangements have been found to be characteristic for some biotypes. The biochemical properties of different biotypes and their genetic base are generally unknown, and studies of these topics are needed to elucidate the causal relations between karyotype variation and biotypes. The best studied case of a chromosomal rearrangement related to a particular biotype is a translocation in Myzus persicae shown to be involved in insecticide resistance (Blackman et al., 1978). Biotypes characterized by high but genetically unstable insecticide resistance have invariably been found to be heterozygous for the translocation (Blackman et al., 1978; Lauritzen, 1982). The insecticide resistance was found to be due to elevated esterase activity (Devonshire, 1977), and although the genetic mechanism is not fully understood, this case has indicated how chromosomal rearrangements can give rise to new biotypes.

54.4.  
8

#### NUTRITIONAL PHYSIOLOGY OF APHID BIOTYPES

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A brief review is presented from the literature and from experiments carried out in the author's laboratory on the feeding behavior and nutrition of aphid biotypes. Possible differences in nutritional requirements (e.g. amino acids, vitamins) that may exist between biotypes are examined. Some aspects of host-plant resistance in relation to biotypes are also discussed.

#### 54.4. 9 FEEDING BEHAVIOR OF APHID BIOTYPES

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Because most aphid biotypes are defined with reference to their occurrence on different host plants or cultivars, it is of interest to compare the feeding behavior of conspecific biotypes on their various hosts. Although several studies have examined the feeding behavior of aphid species on host and non-host plants, fewer investigations have focused on feeding differences between aphid biotypes. In these studies, the duration of ingestion from different tissues, the time taken to reach and ingest from the phloem, and other behavioral details of feeding have been determined by electronic monitoring of aphid probing and by plant histology. These data can be used to illuminate the process of biotype differentiation.

#### 54.4. 10 PLANT INTERCELLULAR MATRICES AND APHID POLYSACCHARASES: THEIR ROLE IN THE INDUCTION OF APHID BIOTYPES

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Many aphids possess flexible styletiform mouthparts which, during the penetration of host-plant tissues, pass between plant epidermal and mesophyll cells before terminating in the vascular bundle. This mode of probing avoids rupturing vacuoles in nontarget cells which can contain deleterious plant compounds (e. g., phenolics). To achieve this sinuous mode of penetration, these stylets pass through a variety of plant biopolymers which are present in the intercellular matrix of various plant tissues. These biopolymers include the polysaccharides, cellulose, pectin and a variety of hemicelluloses; the polyphenolic, lignin; and other less well defined heteropolymers or the polymeric lipid ester, suberin. These polymers are refractory to the usual hydrolytic carbohydrases of most insects. However, the presence in aphids of many different polysaccharases that hydrolyze plant refractory compounds connotes that depolymerizing intercellular biopolymers is required for normal probing and feeding. This relationship between plant biopolymers and differential polysaccharase activity in aphids is associated with plant variety-aphid biotype compatibility. Hence, changes in the nature of these biopolymers through plant breeding induces the formation of aphid biotypes which possess enzymes having improved depolymerizing activity.

S4.5.  
1

## INSECT LOCOMOTION: PAST, PRESENT AND FUTURE

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In the nearly nine years since the last major conference on locomotion was held, research in the field has taken an entirely new direction. In 1975 the major question being asked was, what is the nature of the neural mechanism that is responsible for the generation and coordination of the repetitive movements associated with locomotion in animals? Research on insect locomotion contributed important results that helped to establish the generality that central pattern generators (CPG's) could produce the basic locomotor rhythm without the necessity of sensory feedback. Now, however, there is an entirely different research emphasis, and the main question is, how does sensory feedback from the moving body or its appendages interact with a centrally generated program of motor control to produce the well coordinated and well adapted behavior that can be observed in the intact animal? It seems likely that research on insects will make a major contribution to our understanding of this question as well. In this talk, the major themes of current research as they relate to our understanding of nine years ago, and the likely direction of research in the next few years, will be discussed.

S4.5.  
2

## PROPRIOCEPTIVE CONTROL OF STICK INSECT WALKING

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Walking movements of stick insects are strongly influenced by sensory feedback. Sense organs apparently influence the timing of the "own" leg by determining the transition from one part of the step-cycle (e.g. swing phase) to the following one. They also adjust each part of a step to surface irregularities. The different influences on the pattern generator of a particular leg are apparently superimposed.



**S4.5.** THE INFLUENCE OF POSITION AND LOAD ON THE CONTROL OF LEG  
**3** MOVEMENT IN A WALKING INSECT

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Several experiments performed with walking stick insects are described. The results show that both the position and load of a leg influence whether the leg starts a swing phase or continues its stance phase. The position, load, and state (swing or stance) of the insect's other legs also affect this decision or influence its motor output during stance phase. The results are shown to disagree with earlier models.

**S4.5.** PROPRIOCEPTIVE INFLUENCES ON LEG PROTRACTION IN THE  
**4** STICK INSECT

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Four rows of mechanoreceptive hairs on the coxa of stick insects play a role in posture control and in termination of leg retraction during walking (Baessler, 62, 65). The hair rows also function in intersegmental coordination during stepping: signals from the hair rows of an anterior leg are used to adjust the protraction endpoint of the adjacent posterior leg (Dean & Wendler, 83). The present work describes the organization of this proprioceptive input to the CNS and examines the action of peripheral signals in controlling leg protraction.

54.5. Mechanical Stability In Insects When Walking Straight  
5 Forward And Around Curves.

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In stick insects (*Carausius morosus*) as in many other insects the center of gravity lies in the abdomen near the margin to the thorax. In straight walk many insects use a tripod coordination. This supports the center of gravity permanently in any movement and guarantees the stability of the body against gravitational forces. When a stick insect walks around curves the legs change their coordination and range of movement in such a way, that the center of gravity is always supported.

54.5. THE CONTRIBUTION OF PROPRIOCEPTORS TO THE CONTROL OF  
6 MOTOR PATTERNS OF LEGS IN ORTHOPTEROUS INSECTS

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The sequence, overlap, and coincidence of sensory input from the different proprioceptors of a single insect leg joint already produces a complex pattern of afferent information. Most of this proprioceptive information is used continuously to influence the coordination of the efferent motor patterns which control muscles of the same and neighboring joints.

This network of converging and diverging pathways from proprioceptors to motoneurons was studied for the basal leg joints of locusts from which various various reflex pathways originate. Most of these reflexes are active with little variation in gain but they superimpose their efferent effect, when they converge on the same motoneurone.

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Virtually no terrestrial animal lives in a habitat that is free of significant excursions from the plane of travel. The locomotor behavior of legged animals has evolved to solve problems associated with the traversal of such 3-dimensional terrains. Therefore, an analysis of legged locomotion on 3-D surfaces is essential to a more complete understanding of many biological aspects of walking.

Dr. K. G. Pearson and I filmed *Locusta migratoria* as they walked on a variety of variegated surfaces including those having ditches and steps and on cylindrical dendritic structures. On all terrains tested, these animals used three types of individual leg movements to locate and secure footholds. Despite the relative rarity of these footholds on many experimental terrains *L. migratoria* did not use follow-the-leader gaits to take advantage with the meso- and metathoracic legs of footholds found by legs of the prothorax. However, a novel gait was observed which involved simultaneous or in-phase stepping of legs within a segment when animals traversed rough ground. Experiments designed to elucidate the role of visual information in terrain traversal suggest that vision does not play a significant role in the selection of individual footholds (tactics) but is used in the selection of a gait appropriate to the terrain (strategies). Rather, tactile information appears to be used almost exclusively for locating and selecting footholds.

SENSE ORGANS AND THE PATTERN OF MOTOR ACTIVITY DURING WALKING IN THE AMERICAN COCKROACH.

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During walking, muscles in the legs of insects are active in discrete bursts. These bursts are synchronized with the extension and flexion movements of each leg. Sense organs in the legs (e.g., chordotonal organs, campaniform sensilla and others) contribute importantly to the normal pattern of this motor output. Selective destruction of one or more of the sense organs, or elimination of most of their activity by amputation of the leg, results in changes in the normal pattern of motor activity. Destruction of one organ in one leg has only minor effects, usually decreasing the duration of extensor bursts in that leg. The timing of bursts in one leg relative to those in another is little affected. Eliminating many sense organs by amputating a leg at the trochanter (leaving the coxa and its muscles intact) results in dramatic shifts in phasing between motor bursts in the stump of the amputated leg and those in other legs, and in significant shortening of extensor burst durations in muscles in the stump. At low speeds of walking, there is also a strong tendency for extensor muscles to burst twice within a single cycle of movement of adjacent legs. These results and their significance for the control and coordination of leg movements will be discussed.

**54.5. 9** "STRUCTURE AND PHYSIOLOGY OF THE TERGOTROCHANTERAL DEPRESSOR  
MUSCLE IN THE HOUSEFLY".

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The tergotrochanteral depressor muscle is responsible for the jump which lifts the housefly from the substratum prior to flight. The structure of this muscle has been examined with both the scanning and transmission electron microscope. The fibres comprising the muscle are arranged in straps with the fibres tapering as they reach the point of injection on the apodeme. The passive membrane properties of the muscle fibres have been calculated together with a study of the mechanical responses of the fibres. The mechanical responses indicate innervation of the muscle by three motor axons and this is supported by electron microscope evidence. (Supported by an NIH grant to T.A.M. and M.A. was a Fulbright scholar with support from the Wellcome Trust and the British Council).

**54.5. 10** SWIMMING BEHAVIOUR OF THE WATER BEETLE DYTISCUS  
MARGINALIS L. (DYTISCIDAE, COLEOPTERA).

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Females and males of *Dytiscus* were tethered by wax to the lever of a strain gauge. By lowering this gauge, the experimental animal was dipped in the water of a canal. Following immersion in still water the beetles stroke their mid- and hindlegs for only about 1 s with a frequency ( $f$ ) of about 5 Hz. With frontal water current (speed,  $v = 20$  cm/s), swimming duration increases to more than 1 min ( $f$ , 3-4 Hz). Swimming movements can be elicited by water current, the threshold being at a speed of  $v < 7$  cm/s. Maximal 'swimming speed' (i.e. water-current speed at which the strain gauge returns to 0) of more than 20 cm/s is obtained directly after the start. During swimming the antennae are obliquely stretched forward, the tip of the flagella being bent backwards with increasing speed of the frontal current. The antennae influence several variables of the swimming behaviour (e.g. threshold, duration, legstroke frequency).

#### 54.5. DUAL ROLE FOR OCTOPAMINE IN THE CONTROL OF HAEMOLYMPH LIPID 11 DURING FLIGHT IN LOCUSTA

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Adipokinetic hormones are released from the glandular lobe of the corpus cardiacum soon after the commencement of flight<sup>1</sup>. These peptidergic hormones act upon the fat body to elevate cAMP and release lipid<sup>2</sup>. In vitro studies reveal that the control of release of adipokinetic hormones is via axons within NCCII which synapse with the neurosecretory cells. Pharmacological studies reveal octopamine to be the most likely candidate as the natural transmitter at these synapses<sup>3</sup>. Octopamine is also a neurohormone and can act upon the fat body via cAMP to release lipid<sup>2</sup>.

Thus during the initial stages of flight there is an elevation in haemolymph octopamine<sup>4</sup> which results in an increase in cAMP in the fat body and the initial increase in haemolymph lipid. The adipokinetic hormones are then released and produce a second elevation in fat body cAMP and a further increase in haemolymph lipid. Octopamine therefore plays a dual role as a neurotransmitter and neurohormone in the regulation of haemolymph lipid during flight.

1. Orchard, I. and Lange, A. B., J. Insect Physiol. 29, 639(1983); 2. Orchard, I. et al., Gen. Comp. Endocrinol., 48, 7(1982); 3. Orchard, I. et al., Brain Res. (IN PRESS); 4. Goosey, M. W. and Candy, D. J., Insect Biochem., 10, 393(1980)

#### 54.5. LIPID TRANSPORT TO THE FLIGHT MUSCLES IN LOCUSTA 12

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The major fuel for long-term flight in locusts is diacylglycerol transported to the flight muscles as part of lipoproteins. The supply of diacylglycerols for flight metabolism is controlled by the release of a peptide, adipokinetic hormone (AKH), which mobilises diacylglycerols from triacylglycerol stores in the fat body. Hormone-stimulated release of these diacylglycerols is accompanied by specific changes in the lipoproteins present in the haemolymph; during flight or after AKH injection, lipoprotein *Ayellow* (the major lipoprotein in resting locusts) together with lipids and C<sub>L</sub>-proteins (non-lipid carrying haemolymph proteins) associate to form a new lipoprotein, A<sup>+</sup>. Lipoprotein A<sup>+</sup> supplies lipids to the flight muscles where diacylglycerols are unloaded by means of a membrane-bound lipoprotein lipase. This enzyme hydrolyses lipids associated with A<sup>+</sup> at much higher rates than those on lipoprotein *Ayellow*, and this apparent activation/recognition may be determined by apoproteins present at the surface of A<sup>+</sup> particles. C<sub>L</sub>-proteins which are reversibly bound to A<sup>+</sup> may fulfil such a function, and their possible role in the control of flight muscle lipoprotein lipase will be discussed.

#### S4.5. 13 SENSORY ASPECTS OF FLIGHT PATTERN GENERATION IN THE LOCUST

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Flight movements in locusts are a classical subject in neuroethological research. Results obtained during the last ten years point out that sensory information plays a significant role in the co-ordination of the basic flight pattern. Two sensory subsystems are presented, which fulfill distinct functions within the field of flight control. One of these two subsystems stabilizes the correct alignment of the locust in the air stream: information of wind sensitive hairs on the head is transmitted to an interneurone (TCG), in which it is decoded into information about the yaw angle of the animal. The TCG in turn influences motor neurones in a way, which has been shown to be typical for yaw correcting manoeuvres. The other subsystem monitors the flight movements of the wings (wing hinge stretch receptor). It matches the motor output to the wing kinematics and in addition stabilizes the motor output itself. The interaction of both systems concerning their role in flight stabilization raises questions, which are discussed within the scope of the reafference theory.

#### S4.5. 14 EXPERIMENTS ON THE TEGULA FUNCTION FOR FLIGHT COORDINATION IN THE LOCUST

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During the last years quick phasic sensory input has been proved to be an important part of the locust flight motor ( e.g. the wing hinge stretch receptor, windhairs of the head ). The tegula, a morphologically well known proprioceptor located in the locust wing base was tested for phasic input on motor neurones in flying animals. By means of chronically implanted minute hook electrodes the tegula nerv (NIC1a) was stimulated in a defined time relationship to the flight pattern. The stimulation evoked short latency reactions in the motor neurones of all recorded flight muscles. Motor neurones of the ipsilateral downstroke muscles of the forewing were inhibited within short latency periods, those of the upstroke muscles were excited in the same range. In order to obtain objective criteria to test the significant intervals of the phase specific influences a statistical method for computer analysis using orthogonal polynomials was developed and programmed.

S4.5. CELLULAR BASIS OF SENSORY/MOTOR INTEGRATION IN THE  
15 FLIGHT-CONTROL SYSTEM OF LOCUSTS

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Exteroceptive sensory systems for flight-control in the locust detect course deviations and relay processed information about these deviations to the thoracic ganglia. There this information is channeled to the flight motoneurons by two parallel pathways. Direct pathways cause weak, short latency psp's in the motoneurons. More importantly, powerful indirect pathways involving thoracic interneurons cause strong psp's in the same motoneurons. These powerful indirect pathways require central pattern generator activity for their expression and are thus operative only during flight. Furthermore they are phasically gated by central systems so that they can affect the flight motoneurons only during appropriate phases in the wingbeat cycle.

S4.5. INSECT FLIGHT : NEW FACTS - AND OLD FANTASIES ?  
16

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Spruce budworm (Choristoneura fumiferana : Tortricidae) and African armyworm (Spodoptera exempta : Noctuidae), have now been recorded in flight up to 1000m above ground, in numbers exceeding  $10^{10}$ , at volume densities reaching  $10^{-2} \text{ m}^{-3}$ , travelling with the wind for many hundreds of km and so able to exploit food resources temporarily covering areas up to  $10^5 \text{ km}^2$ , just like Desert Locusts (Schistocerca gregaria : Acrididae). They are all subject in flight to concentration by wind-convergence to population densities of  $10^7 \text{ km}^{-2}$  or more, which account for their pest status but also offer new options for management. These spatial redistributions by flight account for much of the spectacular fluctuations in apparent numbers, and the low densities at which all three species can occur may rarely if ever be significant in their overall population dynamics. Evidence for this conclusion will be outlined, with some of its implications.

S4.5. ACTOGRAPH STUDIES OF LIGHT EFFECTS ON TRICHOPLUSIA NI FLIGHT  
17 ACTIVITY

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4

A thirty two channel computerized actograph is being used to quantitatively correlate light intensity, temperature and humidity with levels of flight activity in the noctuid moth Trichoplusia ni. This paper describes the actograph system and reports results of studies on the effect of changing photoperiod on levels of flight activity.

S4.5. VISUALLY GUIDED CHASING BEHAVIOUR OF HOUSEFLIES  
18

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This account deals with three dimensional flight manoeuvres of houseflies (*Musca domestica* L.). Properties of the flight motor system and the aerodynamic performance of female and male flies are derived from kinematic measurements of 16mm movie films. The incorporation of these results into the analysis of aerial chases and a close inspection of the flight manoeuvres lead to the following conclusions: a distinct difference in the tracking behaviour of females and males occurs in relation to the sexual dimorphism in this species. In contrast to females, males often touch or catch the target on the wing. Males do not merely follow the movement of the target, but can approach and retreat several times. During the approach both sexes try to fixate the target in a "desired" region of the eye (males: fronto-dorsally, females: fronto-ventrally) by controlling rotational and translational components of their movement via the deviation of the target from this region (error angles in azimuth and elevation). The tracking sequences - showing flight path and flight posture of the flies - have been simulated on a computer.



**54.5.** NEURAL CONTROL OF ASYNCHRONOUS FLIGHT MUSCLES IN FLIES  
**19** DURING INDUCED FLIGHT MANOEUVRES

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The spike activity in asynchronous flight muscles (dvm1) of flies is controlled by means of afferences coming from the antennae and from the eyes. - When the aristae of the antennae are bent outwards the spike rate in the dvm1 decreases (*Calliphora*). - When visual gratings are moved in front of the left and/or the right eye the spike rate in the dvm1 is dependent upon the direction of the pattern movement. Visual afferences from each eye influence the spike activities in the left dvm1 as well as in the right dvm1 (*Calliphora* and *Drosophila*). - There are only very small changes of the dvm1 spike rates when flying flies are rotated in complete darkness (*Calliphora*).

**54.5.** INSECT LOCOMOTORY SYSTEMS: CONTROL BY PROPRIOCEPTIVE AND  
**20** EXTEROCEPTIVE INPUTS

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The walking systems and flight systems of diverse insect species are compared to which extent they are controlled by proprioceptive feedback and external stimuli. In the flight system of *Locusta migratoria*, numerous sense organs such as stretch receptors, campaniform sensilla and wind sensitive hairs turn out to be integral parts of the generator of the rhythmic motor output. They operate on the basis of a carrier frequency and respond to external disturbances by change of their phase of activity within the system.

## 54.6. 1 ENVIRONMENTAL ASPECTS OF SOUND COMMUNICATION

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Insect songs may become heavily distorted when they travel through the environment on their way from the singing animal to the listening animals. The distortion may affect the amplitude, the frequency spectrum, and the time structure of the signals. Gradients of temperature and/or wind may create "sound shadows" (an attenuation of all frequencies). Reflecting surfaces and vegetation may attenuate some frequencies and "amplify" others; i.e. cause a substantial frequency filtering of the songs. The frequency filtering may be time-invariant (stationary obstacles) or vary in a fluctuating manner when the obstacles move. The movements may be caused by wind (causing the vegetation to vibrate) or by air turbulence. Both stationary and moving obstacles also cause distortion of the sound signals in the time domain. The insects may use several strategies for communicating in such complex environments.

4

## 54.6. 2 BEHAVIOUR AND AUDITORY FUNCTION IN BUSHCRICKET(TETTIGONIIDAE) HEARING SYSTEMS

DR WINSTON J BAILEY

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Questions directed towards the biophysical function of hearing systems must correlate with the observed behaviour of the insect in its biotope. Theory predicts that in slit-bearing tettigoniids the slit input to the tympanic membrane will function for directional acuity, whereas the tracheal input through the auditory spiracle will function as a broad band high frequency (>15kHz) sensitive system capable of detecting predatory disturbance sounds. We examine the possible interaction of these two systems in an array of acoustic behaviours including: male/male agonistic behaviour, mate finding by the female, male selection by the female and the avoidance of predators. Male Mygalopsis marki (Copiphorini) sing in aggregations where not only the intermale distance is influenced by perceived sound intensity, but also perch height. The cue for this optimum distance is the balance between male attraction and repulsion and can be seen as an interaction between low frequency attraction of the call and the repulsion from high frequency elements in the song. Female Pachysagella australis (Saginae) orient to the male with an auditory acuity of  $\pm 5^\circ$  of arc. Female Conocephalus upoluensis (Conocephalidae) are able to discriminate between males on the basis of both intensity and frequency. The behaviour of M. marki is influenced by ultrasound.

**54.6.** RECOGNITION OF RHYTHMIC FEATURES OF CALLING SONG BY CRICKETS  
**3** (TELEOGRYLLUS OCEANICUS)

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An important cue for recognition of acoustic signals is temporal pattern. We have been studying temporal pattern recognition in the cricket Teleogryllus oceanicus, by measuring phonotactic steering responses of tethered flying crickets stimulated with artificial calling song models. The song of this species is temporally complex; it has rhythmically different chirp and trill sections. This complexity is not needed for species-specificity, since either rhythmic component alone is preferred to a heterospecific song model. The two components differ in their relative attractiveness to conspecific males and females; females prefer the chirp rhythm to the trill rhythm, while the opposite is true for males. It is possible that the complex song permits greater flexibility of intraspecific communication. We have been looking more closely at the specificity of the recognition mechanism in females. Both temporal parameters of the chirp, pulse period and pulse duration, must fall within certain limits for steering responses to be elicited. The effective ranges of these parameters are broad at low intensity, and narrow, to species-typical values, at high intensities. This dependence on intensity is unexpected in view of current thoughts regarding song recognition.

**54.6.** ANATOMICAL REPRESENTATION OF FREQUENCY AND INTENSITY IN THE  
**4** AUDITORY SYSTEM OF ORTHOPTERA

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Using intracellular recording and staining techniques the ordering of auditory fibre endings within the central nervous neuropils was investigated in bushcrickets and locusts. The auditory neuropil of Tettigonia viridissima is tonotopically organized, extending to within the prothoracic ganglion the tonotopic organization of the peripheral sense organ. This kind of ordering is also reflected in the physiology and dendritic geometry of a local interneuron. In an auditory neuropil of the locust axonal endings of high and low frequency receptors are separated; further more the endings are likely to be arranged according to their threshold intensities.

54.6.  
5 THE AUDITORY FUNCTION OF THE TYMPANIC MEMBRANES IN TETTIGONIIDAE  
(ORTHOPTERA : ENSIFERA)

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The auditory organ of tettigoniids is located within the proximal portion of the prothoracic leg tibia. The organ consists of an array of chorodotonal sensilla. These sensilla are supported, at right angles to the main leg trachea, by a membrane which is widest at the proximal end of the array. At the level of the auditory organ the cuticle on the anterior and posterior surface of the leg, thins, to form the tympanic membranes. Although the sensilla within the organ are not directly attached to either tympana, removing the tympanic membranes decreases their auditory sensitivity. Individual sensilla, however, remain tuned to the same sound frequency even when both tympanic membranes are removed.

54.6.  
6 The Effect of the Tympanal Resonances and the Tympanal Surround on the directionality of hearing in the Locust SCHISTOCERCA GREGARIA

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Using two phase-locked sound sources, one closed-field driving the experimental ear via the contralateral tympanum and inter-aural air sacs, and the second a free-field source, we have measured the amplitude and phase properties of the directional response of a single ear. The directionality of the ear is expected to be governed by a set of mathematical boundary conditions at the tympanal surface which depend on both sound pressure and particle velocity. These boundary conditions, because of the resonance of the tympanum and the structure of the cuticle are expected to be dependent upon the angle of incidence of the sound. Our measurements confirm that at super-threshold intensities the resonances of the ear impart a marked degree of directionality.

**S4.6.** A MEANS OF FOCUSING THE AUDITORY PATHWAY ONTO THE  
**7** CONSPECIFIC SOUND SIGNAL IN A CRICKET.

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A pair of large segmental auditory interneurons (omega cells ON1) in the prothoracic ganglion of the cricket *G. bimaculatus* provide enhancement of contrast between auditory interneurons of the sound source adjacent and the opposite body side. The recurrent type of inhibitory circuitry used shows a frequency dependency of action resulting from delayed neuronal feedback. Maximum contrast enhancement is produced if sound patterns of matching sound syllable repetition frequency - it happens to be the syllable repetition frequency of the conspecific communication call - are being processed in the auditory pathway. Calling conspecifics thus leave more precise information about their position with the listening cricket than do all other sound sources.

**S4.6.** THE CHARACTERISTICS AND POSSIBLE IMPORTANCE FOR PHONOTAXIS OF "L"-SHAPED  
**8** ASCENDING, ACOUSTIC INTERNEURONS IN THE CRICKET, ACHETA DOMESTICUS

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In order to evaluate the types and numbers of ascending "L"-shaped acoustic interneurons present in the prothoracic ganglion of a single female cricket, the following procedures were carried out on Acheta domesticus. An acoustic interneuron was penetrated, functionally characterized, filled with lucifer yellow, and killed by illumination with blue light. A second acoustic nerve cell was then penetrated, characterized, and filled with lucifer yellow. These procedures revealed two morphological types of "L"-shaped cells. One type included cells primarily responsive to high frequencies (above 12 kHz). The other type included cells with responses to a broad range of frequencies (2-20 kHz). However, some of these units were more responsive to low frequencies (4-5 kHz) while others were more responsive to high frequencies (14-16 kHz). Unilateral killing of single "L"-shaped cells resulted in changes in phonotaxis which were characteristically different for the types of acoustic interneurons described and helped to understand their possible roles in phonotaxis.

54.6.  
9 PATTERN RECOGNITION BY IDENTIFIED AUDITORY  
INTERNEURONS IN THE CRICKET BRAIN

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4

Three types of auditory interneurons have been identified in the cricket brain by intracellular recording and staining: ascending neurons and two types of local brain cells. The tuning curves revealed broad band neurons and those which are tuned to the carrier frequency of the conspecific calling song in each type of brain cells. Ascending neurons with the best frequency at 5 kHz copy different time patterns of acoustic stimuli very well, while a precise copying is lost in brain cells. On the other hand, ascending cells respond to nearly all time patterns, while specific types of brain cells respond only to those patterns which are effective in phonotactic behavior. So there might exist specific detectors for behavioral relevant acoustic signals in the brain of the cricket.

54.6.  
10 SUPPRESSION OF AN AUDITORY INTERNEURON DURING  
STRIDULATION IN A GRASSHOPPER  
(Chorthippus biguttulus L.)

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Summated nerve potentials were recorded from the neck connectives of unrestrained grasshoppers using permanently implanted steel hook electrodes (30  $\mu$ m). The activity of two auditory interneurons (that of G<sub>1</sub> and B<sub>1</sub> described by KALMRING 1975) was readily discernable due to their conspicuous spike amplitudes.

The activity of these neurones in response to (normally well answered) white noise or chirps ceases whenever the animal stridulates itself. Even the animals own stridulation sounds are not answered during calling song or courtship song.

This suppression remains unchanged even if the animals wings are removed and its stridulation therefore becomes silent. Thus it may be concluded that the suppression can neither be caused by input from wing-hinge proprioceptors nor by acoustic self-stimulation. If the stridulating legs are fixed or even removed (stridulation can still be observed by inserting electrodes into the thoracic muscles) the suppression still appears to occur, but irregularly and fragmentarily. Suppression thus seems to be brought about partly by proprioceptive feed-back from the legs, and partly by central nervous excitation.

**54.6.** DEAFNESS OF ACOUSTIC INTERNEURONS DURING STRIDULATION IN THE  
**11** GRASSHOPPER *OMOCESTUS VIRIDULUS*

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By means of intracellular recordings a number of interneurons has been identified which clearly respond to acoustic stimuli. The complex pluri-segmental structure of these fibres has been revealed by injection of the fluorescent dye Lucifer Yellow. The activity of these interneurons is found to be phasically coupled to the sound producing stridulatory movements which can be released under the conditions of intracellular recordings by brain stimulation. Surprisingly, during stridulation these acoustic fibres do not respond to sound stimuli applied additionally. However, they continue to be active in a song patterned way even if the animal is stridulating silently. Obviously, apart from their property to respond to acoustic stimuli in *resting* animals they play a particular rôle in the neuronal control system of actively stridulating grasshoppers.

**54.6.** RESPONSES TO SOUND OF IDENTIFIED NEURONES IN THE FLIGHT  
**12** SYSTEM OF THE LOCUST LOCUSTA MIGRATORIA

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Sound stimuli directed specifically at the ears can initiate flight in dissected preparations in the locust. Interneurones and motoneurones comprising the flight motor must therefore receive input from the ears either directly or via intercalated neurones. The following aspects of audition and flight were investigated whilst recording from identified interneurones and motoneurones in dissected preparations: (1) The characteristics of sound stimuli for the initiation and maintenance of flight activity; (2) the organisation of auditory inputs to flight interneurones and motoneurones; (3) the modulation of auditory input to an identified flight interneurone. Evidence is presented for the existence of a postflight phase during which sound can initiate flight with a higher probability than normally. The auditory responses during flight of an identified mesothoracic flight interneurone (302) are facilitated during flight induced by wind, but not in flight induced by light or sound. The cellular basis for this facilitation as well as the postflight suppression and subsequent recovery of auditory responses were examined. Some generalisations can be made concerning neurone type (elevator, depressor) and the auditory response to sounds of different frequency, intensity and direction presented before, during, and after flight.

54.7. VIBRATIONAL COMMUNICATION IN INSECTS  
1

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Substrate vibrational communication is widespread in insects. Due to their relatively small size insects have evolved some special kinds of vibratory communication: a) contact vibration, b) nearfield vibratory communication, c) vibrational communication over longer distances (up to 2 m). In the case of contact vibration the sender excites directly the receiver by rhythmic touch. Numerous examples are known (preferentially in social insects) of body to body drumming, or rhythmic touch in the form of antennation, drumming with legs or contact stridulation. Contact vibration seems to play an important role in premating and mating behaviour, in alarm communication and in dominance interactions. Close to the rhythmically moving sender always some mass of the medium oscillates together with the source. So even small insects can communicate over some distance with relatively low frequency signals by means of nearfield vibration.

Vibrational communication over longer distances means that the sender produces waves by rhythmic impact which are transmitted to the receiver through the substrate at medium boundaries (mostly in plant stems).

Although a vibration sense is found in most insect groups, comparatively little is known about substrate vibration; especially about the details of its production, emission, transmission and reception.

54.7. LOW-FREQUENCY AIRBORNE VIBRATIONS IN CRICKETS AND  
2 FEEDBACK CONTROL OF THE CALLING SONG

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In addition to the well known stridulatory sound singing cricket males (*Gryllus campestris* L.) also produce low-frequency airborne vibrations resulting from wing closing and opening. The cercal hair sensilla of the singer itself and of individuals standing near by respond to such signals. When stimulating the cerci of singing males with periodic artificial air puffs the chirp rhythm can be coupled to the stimulus rhythm (if the difference between the two frequencies does not exceed 10%). We conclude therefore, that in singing males one function of the cercus-to-giant fibre system is to be used as a mechanosensory feedback channel which contributes to a stabilization of the chirp rhythm.



**54.7.** PROCESSING OF SPECIES-SPECIFIC LOW FREQUENCY SONG COMPONENTS  
**3** BY INTERNEURONS IN CRICKETS

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Interneurons receiving input from sound sensitive hair receptors on the cerci have been studied during stimulation with electrically produced low frequency sound. 13 ascending interneurons were identified and characterized with respect to their possible function in natural behaviour. The 30 Hz near-field component of the species-specific song of cricket males can be detected by females and non-singing males. In these individuals 4 ascending interneurons on each side are involved in information transmission. The spike pattern contains data about stimulus frequency, position of sound source and changes of this position in the environment. The same neurons in a singing male can be activated through self-stimulation. Additionally several other neurons respond at higher thresholds. In conclusion, the neurons can play a role in phonotactic behaviour as well as in proprioceptive feed back.

**54.7.** THE EFFECT OF ABDOMINAL TRICHOBOTRIA MOVEMENT ON THE RESPONSIVENESS  
**4** OF THE VENTRAL CORD VIBRATORY INTERNEURONS IN NEZARA VIRIDULA L.

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Air particle movement caused by wind or low frequency sound modulates the responses of most of the central vibratory interneurons in *Nezara viridula*. The pentatomide bugs lacking the tympanal organs are able to detect such airborne vibrations with abdominal trichobotria and/or at least theoretically with very sensitive subgenual organs tuned to low frequencies. In one interneurone type the bifunctionality between the leg vibratory system and the system of abdominal trichobotria has been proved. Investigations on the receptor neurons of the subgenual organs have shown that these organs detect airborne sound in their best frequency response range between 150 and 400 Hz with threshold values between 40 and 45 dB SPL.

§4.7.  
5 VIBRATIONAL SONGS OF LAND BUGS AND THEIR PRODUCTION

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In many groups of land bugs (Heteroptera, Geocorisae) stridulatory and tymbal devices for production of vibrational songs are known. Stridulatory structures are more evident and were described by insect morphologists in many groups of bugs. In contrast to this tymbals and possibly other vibration producing structures were previously overlooked in many groups of bugs. In our laboratory such structures were investigated in few species of Pentatomoidea and Reduvioidea by hystological, immobilisation and stroboscopical techniques. For this purpose a special dichromatic LED stroboscopy has been developed to measure a deformation and vibration amplitudes of different parts of insect body. This results are compared with the spectral and amplitude characteristics of vibrational songs as recorded in intact and partially immobilized or surgically altered bugs. A question of the importancy of air-borne and substrate-borne components of vibrational signals in communication is discussed.

§4.7.  
6 VIBRATION BLOCKS HABITUATION OF AN OPTICAL RELEASED  
ANTENNAL RESPONSE IN CRICKETS:

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Targets moving horizontally through the visual field of crickets drive precise tracking movements of the antennae. Repetitions of target movements lead to habituation of the antennal response, i. e. the antennae stop following the target. Habituation is faster when small targets are used. When vibratory stimuli are presented in addition to optical stimuli habituation is either diminished, prevented or dishabituation occurs. We investigate the input system for the effective vibrations and the circuitry where optic and vibrational inputs are mixed.

**54.7.** COPROCESSING OF VIBRATORY AND AUDITORY INFORMATION IN THE CNS OF  
**7** DIFFERENT TETTIGONIIDS AND LOCUSTS

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Comparative physiological studies on the vibratory/auditory systems of different acridid and tettigoniid species show astonishing similarities at the ventral cord level despite great differences in their acoustic/vibratory behaviour, especially in regard to their stridulatory songs. The functional similarities of the different neurons of different species are found even in details. So the perception and processing of conspecific auditory/vibratory signals is probably not the primary function of the relatively highly developed auditory/vibratory system in acridids and tettigoniids.

**54.7.** AIRBORNE-SOUND AND VIBRATION SIGNALS OF BUSHCRICKETS AND LOCUSTS;  
**8** THEIR IMPORTANCE FOR THE BEHAVIOUR IN THE BIOTOPE

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Bioacoustical measurements of airborne- and structureborne-sound from different species of bushcrickets and locusts have been carried out in the biotope and the lab. The stridulating animals of all species produce vibrations on the plants they sit on. But the transmission of structureborne-sound in the different biotopes doesn't allow it to all species to use the combined airborne-sound and vibration signals for a vibrotactical behaviour. E.g. *Tettigonia cantans*, living preferentially in dense bushes, is able to locate the singing conspecific partner by means of sound and vibration. *Decticus verrucivorus* on the other hand, mostly living in the grassland, can't use the combined signals, because the transmission of vibration signals is in their biotope much worse than in dense bushes. The latter has been shown in biophysical measurements.

54.7. 9 PROCESSING OF VIBRATORY SIGNALS IN THE CENTRAL NERVOUS SYSTEM  
OF THE CRICKET

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In the cricket, Gryllus campestris, the responses of subgenual vibration receptors provide two possible cues for central frequency discrimination: differences in mean tuning between groups of receptors in the different leg pairs, and a range of receptors tuned to different frequencies within one subgenual organ.

Most of the ascending vibratory interneurons are highly sensitive in either the low or the high frequency range. Broadbanded neurons are less sensitive. The characteristic sensitivity peaks of these units are mainly due to receptor inputs from a particular leg pair, although most central neurons receive inputs from all six legs. One neuron type, TN1, receives excitatory inputs from both vibratory and auditory receptors; its responses are greatly enhanced by simultaneous presentation of both stimulus modes. On the other hand, the responses of the auditory interneuron, AN2, are inhibited by vibration.

Central processing of vibratory information in the cricket is compared to that of tettigoniids and locusts.

54.7. 10 DISCRIMINATION BETWEEN PREY AND NON-PREY BY THE FISHING  
SPIDER DOLOMEDES TRITON VIA WATER BORNE VIBRATIONS

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The semi-aquatic fishing spider Dolomedes triton (Pisauridae) can respond to water surface waves with an orientating movement. Possible biotic wave producers are terrestrial insects trapped by the water surface, fish swimming close to the water-air interface and - during the mating season - courting conspecifics. While the latter wave signals induce courtship behavior, the former two are correlated with prey capture attempts. Wave signals produced by abiotic sources (such as the wind, falling leaves and water drops) rarely release a response in an ambushing Dolomedes. The behavioral reactions of D. triton to artificial complex wave stimuli was investigated in order to discover which physical parameters within a wave train are used for the distinction of different wave signals. The experimental results show that wave discrimination is primarily based on the evaluation of the time structure and frequency content of a wave stimulus.

54.8.  
1

## Topics in Insect Vision

G.A. Horridge

Although the anatomy of the arthropod eye and the visual behaviour has been studied in detail for a century or more, and the electrophysiology of single photoreceptor cells for 20 years, it is still possible to make great strides forward by relatively simple discoveries in the analysis of the compound eye. Some examples will be briefly reviewed and some of the areas where major discoveries are still being made will be outlined. Emphasis will be on optics, primary receptors studies, recordings from second-order interneurons (lamina ganglion cells) and even upon simple anatomical discoveries.

54.8.  
2

## BIOCHEMISTRY OF TRANSDUCTION IN FLY PHOTORECEPTORS

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In order to gain insight into the molecular mechanism of transduction in insect photoreceptors, we have devised a rapid and simple method for the isolation of 'open rhabdoms' from the ommatidia of the blowfly, Calliphora erythrocephala. This procedure involves the separation of rhabdoms from other cell structures of mechanically disintegrated retinæ by centrifugation on a self-generating Percoll gradient.

In a first study we have examined the phosphorylation of opsin and the cyclic nucleotide metabolism of the retina in relation to the interconversion of rhodopsin (R) and metarhodopsin (M). In the isolated retina opsin is phosphorylated following the conversion of M into R. Experiments performed with isolated rhabdoms show that a high percentage of adenylate cyclase and cAMP phosphodiesterase activities present in the retina is associated with the microvillar membrane of rhabdoms. However, so far we have not measured any light-induced changes of these enzymes activities. Studies are in progress to determine if, during the isolation of rhabdoms, a GTP-binding protein is lost which in vertebrate rods is an essential element of the light-activated cyclic nucleotide enzymatic cascade.

**54.8.**  
**3** EVIDENCE IN FAVOUR OF THE PHOTOPIGMENT MODEL OF INSECT VISION  
FROM THE trp MUTATION IN DROSOPHILA.

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By the use of appropriate light intensities the expression of the trp mutation can be restricted to the peripheral retinula cells in which the visual pigment can also be manipulated predictably affording a means to probe in these receptors the relationship of the visual pigment to the transient receptor potential. Blue-adaptation of w;trp flies by repeated blue light exposures causes them to respond like cn;bw flies deprived of vitamin A in which the dark-adapted rhodopsin fraction is reduced to 0.5% of the normal level. This comparable response behaviour, since the amount of visual pigment in w;trp flies is normal, implies that only some subfraction of the photo-equilibrium value of rhodopsin is available: consistent with the idea of 'active' and 'inactive' subfractions embodied in the photopigment model of fly vision. Furthermore, that one aspect of the trp mutation concerns the metabolic processes providing the energy for rhodopsin activation, and which may be extended to other energy-requiring functions within the visual system. Visual pigment isomerisation is normal because the energy is derived directly from the absorbed photons.

**54.8.** MICROVILLUS, THE UNIT OF PHOTORECEPTOR EXCITATION  
**4** AND ADAPTATION

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In blowfly receptors  $R_{1-6}$ , number of photons absorbed determine the response latency, amplitude and form. Independently of total rhodopsin content, 1) single photons elicit quantum bumps of constant amplitude and duration, 2) when the microvilli absorb synchronously (1.5 ms light pulses), within the range  $10^1$ - $10^6$  (the latter engaging all microvilli), the latency, amplitude and time course are reproducible at any intensity, 3) always  $\approx 500$  photons elicit a signal of  $\approx 30$  mv. It is hypothesized that each of  $1.2 \times 10^5$  microvilli in a rhabdomere acts independently to locally excite the membrane, the summation of such local effects constituting light and dark adaptation. This hypothesis is strongly supported 1) by stimulation and adaptation of a small area of the rhabdomere ( $1\% \approx 1000$  microvilli), 2) by the time course of light and dark adaptation depending on the number of photons per time unit, and 3) by rapid extracellular exchange of  $Ca^{2+}$  concentration by which adaptation can be mimicked. The recent experiments suggest that each microvillus becomes desensitized for some seconds after photon activation.

54.8.  
5

#### COLOUR VISION IN BUTTERFLY EYE

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There are four types of colour receptors in the eye of Papilio with peaks near 380, 450, 550 and 610 nm. With the indifferent electrode in the head, or at a distant place in the retina, the intracellular responses can be positive-going in one part of the spectrum and negative-going in another. A strong electrical inhibition by current flowing from neighbouring cells is confirmed by recording with double electrodes, one inside and one outside the cell. The inhibitory effect of green light on other cell types correlates with the greater number of green cells and is an adaptation to vision against a background of green. The mechanism of the interaction is the return flow of electotonic currents in massed and oriented cells with a high external resistance. As a result, all properties of retinula cells measured in the conventional way are changed by excitation in the surround. The interesting question is whether the retinal interactions are important in vision. If so, they are a general mechanism which favours responses to local or sequential stimuli which affect a few cells as against generalized or simultaneous stimuli, like white light or diffuse light, which excites many receptors at the same time.

54.8.  
6

#### THE COLOR SPACE IN HONEY BEES.

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Behavioral experiments have been conducted to test a color vision model of the honey bee's color vision, which is based on the spectral properties of the photoreceptors. Subjective measures of color similarities allow a quantification of perceptual distance in color space. An initially n-dimensional space of the subjective measures is reduced to a three dimensional space, whose dimensions are compared with the input color vision model.

54.8. PHOTORECEPTORS FOR PHOTOPERIODISM IN THE BEAN BUG,  
7 RIPTORTUS CLAVATUS THUNBERG

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The bean bug, Riptortus clavatus Thunberg (Heteroptera: Coreidae), exhibits a facultative adult diapause which is controlled by photoperiod: The diapause is induced and maintained under short-day photoperiods, and prevented or terminated under long-day photoperiods. The location of photoreceptors for the photoperiodic termination of the diapause was examined by applying a phosphorescent paint. The diapausing adults of which the selected region was painted were kept under photoperiods with photophase a little shorter than the critical value. The results showed that the compound eyes are the principal photoperiodic receptors.

54.8. AFocal APPOSITION OPTICS IN BUTTERFLY OMMATIDIA  
8

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Butterflies and moths are closely related, but the optical systems of their eyes were thought to be so different that it was unclear how the one could have evolved from the other. This problem is now resolved by the discovery of a graded index lens in the proximal part of butterfly crystalline cones. This lens is powerful enough to recollimate the focused beam of light supplied by the cornea into a parallel beam whose diameter is the same as that of the rhabdom. The result is an afocal or telescopic combination of lenses like in the superposition eyes of moths. The ommatidial field of view in this new type of eye is determined by the critical angle of the rhabdom rather than the rhabdom diameter. It also follows from the telescopic design that the distal rhabdom tip is imaged magnified onto the cornea. This unique optical arrangement together with observation and measurement of distinct mode patterns has given us the opportunity to determine in vivo the waveguide characteristics of the rhabdom and the influence of radial pigment migration.



**54.8.** THE LANDING APPROACH OF THE BLOWFLY, *CALLIPHORA*: RELATION BETWEEN  
**9** OPTICS AND BEHAVIOUR

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The landing response (LR) - defined here as upward throw of the foreleg tibiae (Goodman, L.J.: J. Exp. Biol. 37:854, 1960) - was elicited by moving periodic gratings; it depends in a cosine fashion on the direction of stimulus motion. Maximally effective directions of motion (preference direction; PD) vary with the eye region stimulated: in all eye regions tested, PDs are aligned with the z-axes formed by (neur-)ommatidial rows emanating radially from a common origin. This origin coincides with the intersection of equatorial and median planes. (Neur)ommatidial axes were determined by optical means applying the method of Franceschini and Kirschfeld (Kybernetik 8:1, 1971) (Eckert and Land, unpublished experiments).

**54.8.** THE INTERACTION OF EDGE-FIXATION AND NEGATIVE PHOTOTAXIS  
**10** IN THE ORIENTATION OF WALKING GYPSY MOTHS, *LYMANTRIA DISPAR*.

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The visual orientation towards single black stripes and more complex patterns, comprising smooth gradients of brightness was studied in walking gypsy moths. Depending on the width of a black stripe, up to three walking directions are stable within one stimulus situation: towards the centre of the stripe and towards a region within the stripe closer to each edge. The observed responses are explained by a compromise between edge-fixation and negative phototaxis. This hypothesis turned out to be also applicable to more complex patterns. The results allow for some inferences on the central data processing, especially on the shape of the two underlying characteristic curves.

**54.8.** VISUAL PROCESSING AND THE CONTROL OF PREY LOCALIZATION  
**11** AND PURSUIT BEHAVIOR OF THE TIGER BEETLE

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High speed (24 - 50 fps) film analyses of tiger beetles (*Cicindela*) chasing walking flies and moving prey models show that beetles' pursuits vary depending upon visual parameters of the prey. Pursuit of a fly is composed of 3-4 stops alternating with runs. During stops the visual world is stable and the beetle gets visual information about prey angular position and velocity. On average, a shift of the prey image from the receptive field of one ommatidium to that of the next is sufficient displacement ( $3.5^\circ$ ) for prey relocation and run initiation. Such runs are under open-loop control with rotation and translation specified by the previously monitored prey position and velocity, respectively. Run rotation only partially corrects for the prior prey angular position. Such "midline bias" can be adaptive with respect to a probabilistic distribution of prey trajectories. Run translation varies inversely with prey angular velocity, indicating that the beetle may use prey movement as an indirect measure of prey distance.

A beetle pursues high-contrast prey models with continuous rather than open-loop tracking. Prey parameters sampled in the previous 40 ms specify rotation and translation. A cybernetic model of a control system incorporating metric and structural relationships of the prey angular position and velocity to specify a "beetle's" stops, rotation, and translation in simulations produces pursuits which are in close spatial and temporal agreement with actual pursuits of the same prey made by live beetles.

**54.8.** HEAD MOVEMENTS OF THE PRAYING MANTIS WITH PARTICULAR  
**12** REFERENCE TO VISUAL AND PROPRIOCEPTIVE INFORMATION

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In the prey capture behaviour of the praying mantis visual and proprioceptive information is involved in control of head orientation and in determining the direction of the stroke. Neck proprioceptors modify both the magnitude and the angular velocity of head movements generated by visual input. Static position and movement of a mantis' head are associated with tonic and phasic patterns of nervous activity in neck proprioceptors. The primary afferents of neck proprioceptors project into the prothoracic ganglion where they show ventral, dorsal and latero-dorsal arborisations. A main bundle projects onto the mesothoracic ganglion. The dorsal arm of the sensory projection shows an overlap with a neuropile area, which is occupied by neck muscle motoneurons. This overlap suggests functional connections between these two structures.

**54.8.** VISUAL INTERNEURONES IN THE PRAYING MANTIS (MANTIS  
**13** RELIGIOSA)

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Most of the interneurones investigated extend from the lobula to either the ipsilateral cerebrum, the contralateral cerebrum or the contralateral lobula (Co staining). The spike rate in several neurones increases (in others decreases) when moving objects pass through a special area of the visual field. Depending on the class of cell the spike activity may be influenced by small moving objects only (disks) or by different kinds of moving objects (disks, single bars, gratings). All movement sensitive neurones react in a similar manner when the objects move either in a horizontal or in a vertical direction. Some cells show directional preferences. - Information from the lobular interneurones is transmitted to the nerve cord (double recordings).

**54.8.** VISUAL AND MECHANOSENSORY CONVERGENCE ONTO  
**14** UNIQUELY IDENTIFIABLE DESCENDING NEURONS

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In Calliphora a number of different intracellular markers were used to establish the organization of functional connections between sensory receptors or sensory interneurons and descending neurons (DNs) that relay information from the brain to motor areas of the thoracic ganglia. The spatial organization of connections between sensory terminals and DN dendrites is highly specific and consistent between individuals. A certain class of interneuron, defined by its morphology in silver-intensified cobalt fills, always terminates onto specific dendrites of a DN. This basic pattern of organization is exemplified by visual and mechanosensory inputs onto the complex dendritic field of the "Giant Descending Neuron" (GDN). At least three classes of visual interneurons, originating in deep visual neuropil (lobula), project onto specific GDN branches. One of these classes conveys an approximate map of the retinotopic mosaic onto a brush-like array of GDN dendrites. Connections between sensory inputs and the GDN are either via chemical synapses or by mixed chemical/gap-junction synapses. A large posterior branch of the GDN, situated between its visual inputs and axon origin, receives primary afferents from the ipsilateral Johnstone's organ and there is evidence that the distribution of these endings reflects the spatial organization of the receptor organ. The accessibility of the GDN and the identifiability of its inputs makes this a model system for studying the functional significance of dendritic organization of a cell whose participation in escape behaviour is already well documented by other workers.

**54.8.** PROPERTIES OF A SYSTEM OF IDENTIFIED DSMD INTERNEURONS IN THE BRAIN  
**15** OF THE BEE, APIS MELLIFERA.

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Twelve pairs of directionally sensitive motion detecting interneurons have been identified in the brain of the honeybee, Apis mellifera. Their cell bodies lie in either the deutocerebrum or the tritocerebrum with dendritic processes in the deutocerebrum and their axons project to the thoracic ganglia. The direction of the peak response of over 90 DSMD units recorded fell into one of six categories, left or right horizontal, vertical up off-axis left or right, or vertical down off-axis left or right. The numbers of units representing each of the six directions are not distributed evenly within each nerve cord. The implication of this system of DSMD units for the control of optomotor responses in the bee is discussed.

**54.8.** COMPLEX INFORMATIONTRANSFER IN IDENTIFIED FIRST ORDER OCELLAR  
**16** INTERNEURONS

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In the honeybee, the response patterns of large ocellar interneurons (L-neurons) can change several times from graded to spike signals and vice versa during a recording. This suggests the possibility, that L-neurons can use different signals for transmission. Furthermore, non-spiking and spiking responses do not contain the same information: graded responses can be elicited by ocellar light stimulation exclusively, whereas spike responses can be evoked by various sensory stimuli.

It is proposed that L-neurons could transmit different information to different postsynaptic units if certain of their terminal branches would be selective for certain transmission modes. Such a strategy would enable a single cell to fulfill complex functions in information processing in the CNS.

54.9. 1 PHYSIOLOGICAL PROBLEMS FOR PARASITOIDS : A MICROCOSM OF AUTECOLOGY.

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The insect parasitoid stands in relation to its host in much the same way as the individual does to its external environment. This dynamic relationship, once thought of as a simple regulator through food supply, of body size and sex ratio, includes physiological and biochemical interactions that are only now being analysed.

This paper reviews the development of the experimental analysis of the insect host-parasitoid relationship and points to the current investigations that are crucial to the understanding of any biological system - the maintenance and continuity of identity in the face of a challenging and changing environment.

54.9. 2 FATTY ACID AND AMINO ACID COMPOSITION OF TERATOCYTES FROM LYGUS HESPERUS PARASITIZED BY LEIOPHRON UNIFORMIS AND PERISTENUS STYGICUS

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1. Teratocytes (dissociated trophamnion cells liberated from eggs of certain hymenopteran endoparasites into host hemolymph upon hatch) from Lygus hesperus parasitized by Peristenus stygicus or Leiophron uniformis were analyzed and compared.
2. Fatty acid profiles were similar in the 2 types of teratocytes except for myristic acid (C14:0) which was found in higher concentrations in P. stygicus and linolenic acid (C18:3) which was found in higher concentrations in L. uniformis.
3. Of 22 amino acids found in both species, there were 12 that differed significantly between the 2 species (aspartic acid, threonine,  $\alpha$ -aminoadipic histidine, and arginine). Most of these were essential amino acids, and in every case, concentrations were higher in P. stygicus than in L. uniformis associated teratocytes.

54.9.  
3

HELIOTHIS-MICROPLITIS INTERACTIONS AT THE METABOLIC AND ENDOCRINE  
LEVELS

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The parasitoid Microplitis croceipes markedly alters physiological and biochemical processes at two distinct times in its lepidopteran host, Heliothis virescens. The first is through the disruption of carbohydrate metabolism by elevating hemolymph trehalose and preventing a buildup of glycogen reserves in the fat body. The second is the induction of a premature behavioral change and subsequent blockage of developmental processes in the host. Host tissue is still responsive to ecdysteroid injection even though parasitized larvae normally never pupate. Both ecdysteroid and juvenile hormone significantly enhanced parasite emergence. However, when JH-treated larvae were neck ligated, the success of parasite emergence decreased.

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54.9.  
4 EFFECTS OF THE INSECT PARASITE HYPOSOTER EXIGUAE ON THE  
CARBOHYDRATE METABOLISM OF ITS HOST, TRICHOPLUSIA NI

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The host association of H. exiguae is characterized by increased blood sugar and fat body glycogen levels. Elevation of these carbohydrate reserves is accompanied by a increase in the net gluconeogenic flux through the fructose 6 phosphate-fructose 1,6 diphosphate substrate cycle in the fat body. Moreover, the rate of cycling is increased and the maximal enzyme velocities of both phosphofructokinase and fructose diphosphatase are elevated. The above effect could not be explained on the basis of alterations in adenine nucleotide levels and positive substrate "crossover" was not observed. The results suggest that the normal mechanism of metabolic regulation over carbohydrate synthesis is upset in parasitized individuals.

54.9.

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#### FOOD UTILIZATION IN PARASITIZED APHIDS

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Aphidiid parasitoids significantly affected food consumption and utilization in their pea aphid host. Such effects were found to be correlated to parasite development, and were more pronounced in superparasitized hosts than in single-parasitized ones. Characteristically, hosts containing a parasitic larva exhibited increased feeding, reduced assimilation efficiency, and slightly increased weight gain. These results suggested that the parasite affects nutrient utilization in the host which responds by increased feeding. This hypothesis was tested by monitoring phosphate and amino acid utilization in parasitized aphids. While phosphate utilization appeared to be unaffected, there was evidence that parasitized aphids selectively retained amino acids among other food constituents. The results will be discussed with respect to current models of host exploitation by insect parasitoids.

54.9.

6

#### IN VITRO CULTURE OF INSECT ENDOPARASITES

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Two braconids (*Cotesia marsiniventris* and *Microplitis croceipes*), endoparasites of lepidopterous larvae, were cultured in artificial media. Newly-laid eggs of these wasps failed to develop in vitro unless host fat body also was present, but eggs that had already attained the germ band stage when explanted continued development. The larvae hatched but while many attained apparent competence to molt to the second instar, none did so. A qualitative change in their environment, such as a hormonal cue from the host, may be required to elicit molting.

Preliminary findings on the artificial culture of an endoparasitic tachinid (*Compsilura concinnata*) will also be presented.

54.9. STRATEGY FOR ACHIEVEMENT OF PARASITOID REARING ON ARTIFICIAL MEDIA  
7 ILLUSTRATED BY SOME EXAMPLES.

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One successful way to obtain satisfying results in this field can be summarized as follows : 1 - Correct knowledge on the parasitoid development, especially the larval growth, has to be obtained in order to get in vitro rearing references. (i.e. developmental arrest in the tachinid fly P. insidiosa). A special attention has to be taken for definition of true larval food.

2 - The diet composition may be based either on food analysis (host or part of it) or on serial analysis of whole growing parasitoids (i.e. amino-acids analysis of three different tachinid larvae).

3 - The artificial media are so complex that it is necessary to take into account the different components interreactions at preparation time. A key factor is the osmotic pressure which must be strictly adjusted for some species. In this way proteins and polysides must be used instead of free amino-acids and oligosides. Sterilization by heating needs a preliminary processing of proteins. Perhaps irradiation although having negative secondary effects should be a better alternative procedure.

4 - The experimental plans must allow multifactorial interpretation to study the complex interactions between the medium components and the various expressions of the results (i.e. canonic regressions analysis).

54.9. HOST-PARASITE INTERACTIONS IN ANAGASTA KUEHNIELLA  
8

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An ovo-larval parasite, Phanerotoma flavitestacea (Hym. Braconidae) induce an important decrease of dry weight and analysed substances in Anagasta kuehniella caterpillars (Lep. Pyralidae).

In the healthy caterpillar, the weight increase from the L<sub>4</sub> to the nymph (increase : 13 times). This of parasitized caterpillars increase to the beginning of the last instar then decrease after the cocoon spinning. (increase : 3,5 times)

More the caterpillar is aged, more the difference between the two types of caterpillars is high : weight : 14% (L<sub>4</sub>) to 77% (end of the last instar); lipids : 55 to 81% ; glycogen : 9% to 75% ; nitrogenous compounds : 40 to 77%.

Relative to the dry weight unit, the quantities of lipids and glycogen are sometimes more important in parasitized caterpillars.



**54.9.** RATE OF DEVELOPMENT: ITS INFLUENCE ON WEIGHT AND LARVAL COMPETITION  
**9** IN APHID PARASITES

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Several aspects related to larval development and growth of aphid parasites (Hymenoptera: Aphidiidae and Encyrtidae) are examined. Host size at parasitization and parasite growth / size are functionally related. The adult weight of Aphidius smithi increased with host weight up to a threshold value, when increased host weight did not result in added parasite weight. In Diaeretiella rapae, the rate of development varied with initial host size, with larvae requiring more time to complete development in small than in large hosts. The rate of development can be sexually dimorphic (Aphelinus howardii). The rate of embryonic development and the length of the first instar are of importance in contest-type competition between Aphidius smithi and Praon pequodorum. The more variable and slower rate of embryonic development favoured Praon to reach the first instar after Aphidius and to eliminate the latter by physical combat.

**54.9.** DEVELOPMENTAL INTERACTIONS BETWEEN COMMON  
**10** ARMYWORM AND ITS PARASITOIDS

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In the field the common armyworm, Leucania separata larvae are parasitized by Microplitis mediator, Apanteles ruficrus and A. kariyai. Parasitized hosts were smaller than unparasitized one. Especially, M. mediator, a solitary parasitoid, markedly inhibited the growth of host, while in the case of gregarious ones (A. ruficrus and A. kariyai), heavily parasitized hosts have a larger host than lightly parasitized ones. In both cases, after the weight of host larvae including parasitoids reached the certain level, host larvae stopped to feed and the weight of the hosts began to decrease. This shows that the growth of host is not only regulated by parasitoid female as reported by many authors, but also controled by her offspring, parasitoid larvae hatched.

54.9,  
11

PATHOLOGICAL RESPONSES OF LEPIDOPTERAN EGGS TO PARASITISM BY  
SCELIONIDS AND TRICHOGRAMMATIDS

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4

Successful development of some scelionids and trichogrammatids depended on their ability to disrupt host egg development. Ovipositing females injected venoms which arrested host development. Necrosis of host tissues occurred prior to or coincident with parasite eclosion. In the case of scelionids, host necrosis was primarily due to cytolytic enzymes produced by teratocytes, while in trichogrammatids necrosis appeared to be due to the adult produced venom. Larval feeding damage was not found to be an important factor in successful parasitism. Host arrestment allowed parasites of both families to successfully parasitize hosts throughout most of the egg stage while preoral digestion of host tissues greatly facilitated rapid parasite development.

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PHYSIOLOGICAL EFFECTS OF PARASITISM BY APANTELES CONGREGATUS AND  
HYPOSOTER EXIGUAE IN THE TOBACCO HORNWORM, MANDUCA SEXTA

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In Manduca sexta larvae parasitized by the gregarious braconid wasp Apanteles congregatus, the host's ecdysteroid titer rises during its terminal stage and stimulates emergence of the parasites. The host itself shows no morphological response to the ecdysteroid increase, probably due to lack of conversion of ecdysone to 20-hydroxyecdysone, the active form of the molting hormone, and other factors. Parasitism also causes an abnormal elevation in the host's juvenile hormone titer, attributable to decreased synthesis of juvenile hormone specific esterase. Parasitism also induces the appearance of a new protein in the hemolymph of the host larva and reduces the level of hemolymph phenoloxidase activity.

In contrast to larvae parasitized by A. congregatus, hosts parasitized by the solitary ichneumon Hyposoter exiguae invariably undergo apolysis in preparation for larval molting 24 hours before the wasp larva consumes the host carcass and emerges. Since apolysis occurs, it appears unlikely that synthesis of 20-hydroxyecdysone is disrupted. Nevertheless, the temporal correlation between the occurrence of host apolysis and the subsequent emergence of H. exiguae suggests this parasite may be similar to A. congregatus and emerge in response to an increase in the host's ecdysteroid titer.

This research is supported by grants from the National Science Foundation (PCM-8216013) and the U.S. Dept. of Agriculture (83-CRCR-1-1221).

**S4.9.**  
**13**

ANTI-JUVENILE HORMONE EFFECTS IN LARVAE OF TRICHOPLUSIA NI  
PSEUDO-PARASITIZED BY CHELONUS SPP.

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Larvae of Trichoplusia ni and many other Lepidoptera precociously initiate metamorphosis when parasitized by wasps in the genus Chelonus. Metamorphic development is then blocked during the precocious prepupal stage. This dual effect of host regulation by the parasite is observed in 'pseudo-parasitized' larvae, which do not contain a parasite at the time the endocrine disturbances become manifest. Experimental results on pseudoparasitized larvae indicate that the first endocrine disturbance, which resembles an anti-juvenile hormone effect, is not merely chemical allatectomy. Rather, the entire developmental program of the last instar feeding stage is prematurely expressed in the penultimate instar, leading to precocious commitment toward metamorphosis. The second endocrine disturbance also appears to be an anti-juvenile hormone effect. Experimental results are consistent with an abnormally low prepupal juvenile hormone titer, which in turn results in insufficient ecdysone to stimulate a pupal molt.

**S4.9.**  
**15**

ENDOCRINOLOGICAL INVESTIGATIONS OF THE HOST-PARASITE-SYSTEM:  
PIERIS BRASSICAE L. - APANTELES GLOMERATUS L.

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The jh titer of the hemolymph of *Pieris brassicae* parasitized at various times by *Apanteles glomeratus* was investigated by Galleria bioassay during the last larval instar.

Compared to unparasitized caterpillars the parasitized larvae show an elevated jh titer dependent on time of parasitization. Ligation experiments let suppose that the parasite larvae during their 2nd instar are the source of the increased jh titer of the host's hemolymph.

**54.9.** IDENTIFICATION AND MAPPING OF CAMPOLETIS SONORENSIS  
**16** VIRUS mRNAs PRESENT IN HELIOTHIS VIRESCENS LARVAE

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Campoletis sonorensis Virus (CsV) mRNAs present in parasitized Heliothis virescens larvae were investigated by northern blot analysis. At least six viral mRNAs were detected with CsV DNA probes. Cloned CsV DNA fragments homologous to the viral mRNAs were subsequently identified and used to map CsV transcripts to the superhelical molecules of the CsV genome.

**54.9.** PRODUCTION AND EFFECTS OF AN ANAL SECRETION OF THE ENDOPARASITIC  
**17** LARVA PIMPLA TURIONELLAE (L.) (Hymenoptera: Ichneumonidae)

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The endoparasitic larva of Pimpla turionellae discharges a clear secretion by its anus. This fluid obviously is produced by four hypertrophied larval Malpighian tubules and by glandulous sections of the hind gut. Predominating contents of the secretion besides water are hyaluronic acid and compounds positively reacting to ninhydrine.

Essential physiological effects of this secretion have been stated to be (1) inhibition of phenoloxidase, thus delaying melanization of host hemolymph, and (2) antibacterial and fungistatical action, which prevents septicaemia or fungal infections of the host body.

54.9.  
18 THE HYPOSOTER EXIGUAE CALYX VIRUS: ITS APPEARANCE DURING THE  
ONTOGENY OF THE FEMALE AND ITS EFFECTS ON TRICHOPLUSIA NI,  
THE HOST INSECT OF H. EXIGUAE

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The calyx virus of Hyposoter exiguae is first seen in electron micrographs of hemocytes in pupae 48 hr. after cocoon spinning. The virus appears to migrate into the cells of the calyx region of the lateral oviducts and form virogenic stromata 107 hr. after spinning. Progeny viruses produced by the virogenic stromata begin migrating into the oviduct lumen before the adult female emerges from the cocoon. Purified virus preparations are responsible for the weight-gain and hemolymph-protein anomalies symptomatic of parasitism in Trichoplusia ni.

54.9.  
19 ROLE OF APANTELES GLOMERATUS VENOM DURING PARASITISM

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Most of the eggs, deposited by the female parasitoids from which the venom apparatus was removed, were encapsulated in the usual larval host, Pieris rapae crucivora, within 2 days after oviposition. The results give direct evidence that the venom is an important factor inhibiting the host encapsulation reaction to Apanteles eggs. However, the venom may not block the ability of the host to encapsulate other foreign materials except Apanteles eggs. The results suggest that the venom and the fibrous outer layer on the surface of Apanteles eggs act synergistically to suppress the hemocytic encapsulation of the host.

P4.1.-

1

## ARYLPHORIN, A CONSTITUENT OF THE SCLEROTIZED INSECT CUTICLE

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The involvement of arylphorin (=Calliphorin) in the formation of the cuticle of the blowfly *Calliphora vicina* has been investigated. Cuticles were homogenized and subsequently extracted by a series of solvents: acetone, 0.1M NaOH, H<sub>2</sub>O, 2% HCl, H<sub>2</sub>O, 1M NaOH, 50% acetone, acetone, H<sub>2</sub>O. The last pellet was purified chitin. The presence of arylphorin could be demonstrated in the first NaOH and water fraction. This indicates that arylphorin could be utilized in sclerotization.

Radioactively labelled (H<sup>3</sup>)-arylphorin was injected into 7 days old larvae. About 10% of the radioactivity was incorporated by the puparia, which were processed for chitin as above. Radioactive label could be measured in both NaOH, first water and both acetone fractions. This suggests that arylphorin could form a complex with chitin in the cuticle. These results will be confirmed by in vitro binding studies with highly purified chitin and arylphorin.

From our experiments can be concluded that arylphorin is deposited in the cuticle both in soluble and insoluble form. In the insoluble form it might be converted per se into tanned insoluble protein and/or the phenylalanine residues of arylphorin are hydroxylated into tyrosine during sclerotization of the cuticle.

## P4.1.- OVICIDAL ACTIVITY AND DEVELOPMENT INHIBITION IN THE GRANARY 2 WEEVIL BY CERTAIN INSECT GROWTH REGULATORS (IGRs) .

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In laboratory tests, the three IGRs, BAY SIR 8514, diflubenzuron, methoprene and two of their mixtures were evaluated for their ovicidal activity and suppression of progeny development of the internal feeder, granary weevil, *Sitophilus granarius* in wheat grain.

The three tested compounds as well as their two mixtures at concentrations ranging from 0.5 to 20 ppm each exhibited pronounced ovicidal activity against newly deposited eggs (0-day old) much more than the older ages of 1-8 day, realized laterly in the reduced numbers of F<sub>1</sub> emerged adults. In terms of progeny inhibition, the urea-type IGRs, BAY SIR 8514 and diflubenzuron demonstrated appreciably higher activity against both 0-day old eggs and the subsequent developmental stages, whereas methoprene showed meager activity and resulted in high numbers of emerged F<sub>1</sub> adults. Moreover, oviposition appeared to be stimulated by methoprene at concentrations below 5 ppm.

Direct application of IGRs and their mixtures on older eggs of 1-8 day old inside the kernels, showed that both urea-type IGRs being also somewhat more active than methoprene and causing decreased productivity with increasing concentration.

P4.1.-  
3

COMPENSATION OF DIFLUBENZURON EFFECTS BY 20-OH-ECDYSONE  
IN TENEBRIO MOLITOR PUPAE.

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Tenebrio molitor pupae taken just after ecdysis and dipped in an acetone solution of diflubenzuron ( $1 \text{ g.l}^{-1}$ ) are unable to carry on further development.

Particularly, in the epidermis, the mitotic crisis and DNA synthesis preceding the new adult cuticle secretion do not occur and the animals remains apolyzed until death. Moreover, the pupal ecdysteroid peak associated with the mitotic period is absent.

Such blocked pupae injected with 2 to 10 ug 20-OH-ecdysone several days after diflubenzuron application, are able to secrete a new cuticle characterized by an abnormal architecture and by a high content in N-acetyl amino sugars as visualized by fluorescent wheat germ agglutinin.

However, 20-OH-ecdysone injection is unable to initiate significant mitoses or DNA synthesis in the epidermis. Such results strongly suggest that diflubenzuron acts on other mechanisms than chitin synthesis.

P4.2.-  
1

MULTIOSCILLATOR AND COUPLING: COMPARATIVE NEUROBIOLOGICAL ASPECTS OF THE  
CIRCADIAN CLOCK SYSTEM IN INSECTS AND OTHER ARTHROPODS

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The sensitivity of the compound eyes of many arthropods and the level of spontaneous locomotor activity of these animals as well are endogenously controlled by circadian clock systems. Those biological clocks are organized as multi-oscillator systems. The type and strength of the internal coupling mechanisms between the oscillators determine the overt rhythm which the animal shows. From very tight mutual and hierarchical coupling to weak and nearly absent internal coupling several situations are possible.

The poster compares the results of behavioral and electrophysiological experiments with a weakly coupled clock system of beetles and the tightly coupled system of scorpions.

P4.2.-

## STUDIES ON NEUROSECRETORY SYSTEM OF

### 2 HETEROPTERA. NEUROSECRETORY CELL TYPES

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4

There are four types and their six types of neurosecretory cells, noticed in the pars-intercerebralis region in the brain of the heteropterans bugs. They have been designated as A1, A2, B1, B2, C. and D types on the basis of their staining behaviour and cell measurements. If their staining behaviour with CAHP is taken in to account, the A and B types of cells of the present study are most easily comparable with the A and B types of cells of Iphita limbata (Nayar 1955a). Nayar based his description on material stained in Chrome Alum Haematoxylin Phloxin. His A and B type cells show the same tinctorial affinities as the similar types of cells in the heteropterans bugs studied here. The A and B cells of Oncopeltus fasciatus (Johansson, 1958), also show the similar staining behaviour with CAHP as described by Nayar (1955). Hence the A and B type of cells as designated in this study are similar to the A and B cells of Iphita limbata (Nayar 1955) and Oncopeltus fasciatus (Johansson, 1958).

### P4.2.- INTERACTION OF PHEROMONE MOLECULES WITH THE ANTENNAE OF 3 MALE ANTHRAEA POLYPHEMUS.

SUDHA KANAUIA

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For these studies, tritium labelled-pheromone of female A. polyphemus ( $E_6-Z_{11}$  hexadecadienyl acetate) and freshly isolated antennae of living male moths were used. Male antennae adsorbed up to 30% of the pheromone molecules contained within a passing air stream. This demonstrates the high effectiveness of antennae as an odour filter. 120 seconds after exposure, the amount of radioactivity adsorbed on the antennae initially (0.2 sec) had decreased by approximately 20%. Thus, desorption plays a minor role in stimulus removal. One minute after exposure, about 70% of the total number of molecules adsorbed are located on the hairs. With increasing time they migrate towards the antennal branch. Two minutes after exposure, about 70% of the molecules adsorbed on the hairs are located on the distal half of the hairs and the remaining 30% are located on its proximal half. These studies indicate that pheromone or related metabolic products are present on the hairs long after the decline of physiological responses.



**P4.2.-**  
**4** DEVELOPMENT OF METABOLIC CAPACITIES IN INSECT  
CEREBRAL GANGLIA DURING ONTOGENESIS

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Brains of some insect species have a unique capacity to oxidize fatty acids in addition to glucose and ketone-bodies to meet their energy requirements. The formation of this unusual metabolic organization has been followed by measuring a) the activity of enzymes representing main pathways of energy metabolism and b) the ability of isolated brains to catabolize exogenous [U-  $^{14}\text{C}$ ]-glucose or [3- $^{14}\text{C}$ ]-acetoacetate during development of *Bombyx mori* and *Manduca sexta*.

In the early pupal phase (P1) the enzyme activities fall to low levels compared to those in the last larval instar (5.LS), rise again at the end of metamorphosis (P2) and build up their imaginal enzyme patterns which indicate an improved capacity for fatty acid oxidation.

The rates by which exogenous substrates are oxidized by isolated ganglia run parallel to the developmental changes in enzyme activities. When both substrates are offered in saturating concentrations to isolated ganglia of adult *Manduca* the rate of oxygen consumption is not affected, but acetoacetate can compete successfully, reducing the rate of glucose oxidation. The opposite is not valid.

Supported by Deutsche Forschungsgemeinschaft, Bonn

**P4.2.-**  
**5** CHANGES IN PERIPHERAL SENSITIVITY IN ASSOCIATION  
WITH INDUCTION OF FOOD PREFERENCE.

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Dietary experience of plants, or of chemicals in artificial diets, induces changes in the preference of insects for these plants or chemicals and the effect differs between oligophagous or polyphagous species. By correlating the results of electrophysiological and behavioural experiments we have investigated the sensory basis of this phenomenon. We have shown that different mechanisms operate in different insects and that the effect can apply with phagostimulants as well as allelochemicals.

P4.2.-  
6 INNERVATION OF THE CORPORA ALLATA IN THE HOUSE CRICKET

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The innervation of corpora allata in the house cricket Acheta domesticus has been studied using retrograde transport of horse radish peroxidase. A crystal of HRP was implanted in vivo in the corpus allatum. After 18 to 24 hours the brains were dissected out and fixed ; the HRP was then visualized according to standard methods. The corpus allatum is innervated by lateral neurosecretory cells of the protocerebron. About ten somata are ipsilateral and about two are contralateral.

P4.2.-  
7 IMMUNOCYTOCHEMICAL LOCALIZATION OF PEPTIDERGIC AND AMINERGIC NEURONS  
IN THE NERVOUS SYSTEM OF THE COLORADO POTATO BEETLE.

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Distinct neurons in the nervous system of the Colorado potato beetle, *Leptinotarsa decemlineata*, are recognized by antisera against serotonin and the following peptides: proctolin, adipokinetic hormone, crustacean hyperglycaemic hormone, FMRFamide, bovine pancreatic polypeptide,  $\alpha$ -MSH,  $\gamma$ 1-MSH, motilin, gastrin, gastrin releasing peptide, somatostatin, vasopressin, vasotocin, oxytocin, rat prolactin, ovine prolactin,  $\alpha$ -endorphin,  $\beta$ -endorphin, corticotropin releasing factor, insulin, ACTH.

At least 18 different peptidergic cell types can be distinguished in this way. Some neurons have extensively branched axons in the neuropile, others innervate the corpus allatum, suggesting that the peptide is used as a neurotransmitter/modulator. Also in the corpus cardiacum immunoreactive materials are present and presumably released as hormones.

Experiments showed that immunocytochemically detected peptides are not always related to the peptides used as antigens for the antisera. Thus in some neurons antisera against  $\gamma$ 1-MSH, FMRFamide and bovine pancreatic polypeptide recognized the same insect peptide.

These results show that immunocytochemistry with antisera against biologically active peptides can be useful for mapping peptidergic networks. However only partial information is obtained as to the nature of the peptides involved.

P4.3.-  
1

## LARVAL DIAPAUSE AS AN EVOLUTIONARY MODEL OF APHID HETEROGONIC CYCLES

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Three different aphid species, experimentally reared at low temperature (4-5°C.) reacted differently in relation to the peculiar feature of the own cycle. Parthenogenetic females of Acyrtosiphon pisum (Holocyclic species) undergo embryonic degeneration in conditions of prolonged low temperature and die after about 25-30 days, while Macrosiphum rosae, a known paracyclic species, undergoes larval diapause after few days of low temperature and survived indefinitely. Two sexual races of Megoura viciae (A: holocyclic race and B: paracyclic race) (Bonvicini Pagliai 1983, Atti XIII Congr. Naz. It. Ent.) react to prolonged low temperature according to the A. pisum model (race A) and to the M. rosae model (race B), respectively. M. viciae, therefore, may be regarded as a transition-model of evolution between holocyclic and paracyclic species. In paracyclic forms (M. viciae, race B and M. rosae) the winter diapause is shifted to the larval stage (as in the hiemales of Sacchiphantes abietis), thus permitting the overwintering of parthenogenetic larvae and suppression of the amphigonous generation.

P4.3.-  
2

## EFFECTS OF AGE ON THE REPRODUCTIVE PHYSIOLOGY OF FEMALE MOSQUITOES

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Reproductive physiology of female mosquitoes conventionally is investigated within one week of adult eclosion, mostly because at this time mortality usually is lowest in the experiments. Yet mosquitoes become vectors of many diseases only when certain conditions are met: at least one gonotrophic cycle needs to be completed and in most cases the pathogen requires a species-specific incubation time within its vector in order to acquire full infectivity. All these conditions add to the age of the female and a quantitative analysis of the underlying physiological changes in the female metabolism is called for.

Two basic aspects of the gonotrophic cycle have been investigated in this laboratory so far with respect to the chronological as well as the physiological age of the female Aedes aegypti: the processes of blood digestion with emphasis on the proteolytic system, and of oogenesis. Recent results on the age-dependence of oogenesis and fecundity will be presented and related to behavioral aspects, as reported by other laboratories.

P4.3.-  
3

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The Effects Of Radiation On The Biological And  
Inheritable Variability of Insects

4

When the pupa of a insect is treated With Radiation,  
mitochondria centriole and other organelles are destroyed and  
sperm lose its activity. Powerful disruptive enzymes in the  
lysosomes destroy organelles in the germ cell, including sperm and  
ova. Radiation must be given before meiosis in order to produce  
mutants. Thus sterilization is effected. This research was done  
by use of light and electron microscope.

P4.3.-  
4 INVESTIGATION OF THE HAEMOLYMPH OF LARVAE OSTRINIA  
NUBILALIS DURING THE DIAPAUSE

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The cold-hardiness of diapausing larvae Ostrinia nubilalis  
was investigated. It is found that the field larvae freeze at  
about  $-20^{\circ}\text{C}$ , in the low temperature periods. Haemolymph osmotic  
concentration increases during the winter, and decreases in early  
spring. It is concluded that there are changes in the level of hae-  
molymph glycerol, trehalose and in the amount and types of amino  
acids during the diapause (in September, January and April) in  
the larvae of these insects. The highest concentration of glyce-  
rol in January larvae is accompanied by decrease in an insect's  
total glycogen reserves. Furthermore, the highest haemolymph phos-  
phatase activity of January larvae confirms the supposition of  
the carbohydrate origin of glycerol. We did analysis of the hae-  
molymph proteins of the same insects by electrophoresis in cellu-  
lose gel. We noticed the clear presence of a fraction in the hae-  
molymph of the January larvae which doesn't exist in the April  
larvae. This fraction of protein is glycoprotein. These seasonal  
changes in blood chemistry as defense against cold, are the basis  
for understanding of cryoprotective mechanism of this insect in  
the diapause.

**P4.3.-** EFFECT OF SUBLETHAL DOSES OF GAMMA RADIATION ON THE  
**5** FECUNDITY AND STERILITY OF ADULTS OF SITOTROGA CEREALELLA  
(OLIVIER).

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Experiments were carried out to study the effect of sub-lethal doses of gamma radiation (10-100 Krad) on fecundity, longevity and sterility of adults of S. cerealella. The present results indicate that fecundity of females decreased as the dosage increased from 10 Krad up to 90 Krad. At 100 Krad no eggs were deposited. Raising the dose to 100 Krad resulted in shortening the longevity to about ½ the longevity of the untreated moths. When irradiated females mated with similarly irradiated males, a dosage of 20 Krad caused 97.17 % sterility. A dose of 28 Krad induced 96.69 % sterility when normal females were mated with irradiated males, while 98.14 % sterility resulted when the opposite mating was happened.

**P4.3.-** EFFECT OF GAMMA RADIATION ON THE DIFFERENT STAGES OF THE  
**6** ANGOUMOIS GRAIN MOTH, SITOTROGA CEREALELLA (OLIVIER)

I.I. ISMAIL\*, A.K.M. EL-NAHAL\*, A.H. KAMEL\*\* AND T.S.  
MOSTAFA\*\*

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\*\* Plant Protection Res. Inst., Ministry of Agric., Egypt.

Experiments were carried out, to study the effect of gamma radiation on the different stages of S. cerealella. The susceptibility of the different stages of the insect to gamma radiation could be arranged in a descending order according to LD50 as follow : Adults (190 Krad for females and 183.200 Krad for males); pupae (6.039 Krad); 3-day old eggs (5.570 Krad); 1-week larvae (4.800 Krad); 1-day old eggs (4.181 Krad), 2-week old larvae (3.056 Krad).

**P4.3.-** THE INTERVAL TIMER ON THE LIPAPHIS ERYSIMI AND ACYRTHOSIPHON PISUM.  
**7**

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When stem mother's first-born and last-born lineage of Lipaphis erysimi and Acyrthosiphon pisum were separately reared for several generations continuously under short-day ( 8L16D, 12L12D ) conditions at temperature of 15°C, the sexual forms began to appear in the 3rd or 4th generations and the rate of appearance increased with the progressive generations. More short-day condition of 8L16D appeared to give a higher proportion of sexual forms than that of 12L12D. Also a higher proportion of sexual forms was produced in the last-born lineage than the first-born one.

**P4.3.-** Diapause and post-diapause development in the adult female of Colorado  
**8** potato beetle: Leptinotarsa decemlineata Say.

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It is well documented that diapause in the adult Colorado potato beetle is induced by short daylengths. This inducement is partly caused by the extremely low levels of juvenile hormone (JH) in the haemolymph, which result from a low corpus allatum activity (CA) and a high rate of hormone breakdown by JH-esterases, during the pre-diapause period. This poster is an extension of the study of JH-homeostasis during diapause development and termination.

Experimental techniques included measurements of CA activity in vitro, JH haemolymph titre determinations by radioimmunoassay and estimations of JH-esterase activities in the haemolymph. In addition, the influence of external factors, such as photoperiod and temperature, on JH-homeostasis during diapause and post-diapause development are described. Finally, factors involved in diapause termination (such as exogenous JH applications and allatectomy) were investigated.

**P4.3.-** SOME FACTORS INDUCING MALE SEX DETERMINATION IN THE APHIDS MEGOURA  
**9** VICIAE BUCKTON AND ACYRTHOSIPHON PISUM HARRIS.

MARISA MARI, ENZO ORLANDO

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A comparative study on the determination of male sex has been carried out in two species of aphids, Megoura viciae Buckton and Acyrtosiphon pisum Harris. In addition to photoperiodic length the influence of some other factors such as fasting, temperature variations and host plant, has been studied.

Although the utilised strains gave no male births in long photoperiod regime some males were born when parthenogenetic mothers were subjected to appropriate fasting treatments.

**P4.3.-** CHEMICAL INTERACTION IN LARVAL BLOODSACKING MOSQUITOES  
**10**

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We studied influence of cultural water containing products of mosquito larvae life activities (exometabolites) upon their growth, development, survival. Cultural water from the 4th instar larvae, with density of 0,5-1,0 ("crowd water") and 0,05 larvae per ml, was used to keep the 2nd instar larvae. "Crowd water" from *Aedes caspius dorsalis* and *Culex pipiens* reduced growth, development and survival of their proper species larvae. The action of cultural water from larval "populations" of low density was qualitatively different. Those mosquitoes reactions upon the metabolites are specific for each species. The effect of the intact and diluted "crowd water" was the same in *A.c.dorsalis* but not in *C.pipiens*. It was established, that metabolites of *A.c.dorsalis* and *A.vexans* larvae stimulated growth and development in those of *C.pipiens*.

**P4.3.-** METABOLIC CONVERSIONS OF SOME AMINO ACIDS COUPLED WITH SUGAR  
**11** METABOLISM UNDER ANOXIA IN DIAPAUSE EGGS OF SILKWORM

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The presence of cytochrome c has not been detected in diapause eggs of silkworm, Bombyx mori, from oviposition to the onset of reviviscence. Under this anoxic condition  $\text{NADH}_2$  overproduced in glycolytic pathway inhibits the pyruvate dehydrogenase complex and this leads to formation of high amounts of alanine and the simultaneous interconversion of glutamate and 2-oxoglutarate catalysed by transaminase and glutamic dehydrogenase. During diapause a decrease in alanine caused by the normalization of redox balance results in the accumulation of proline as well as glutamine which are utilized as an energy source along with glycogen during secondary embryonal development after diapause. At this period, a well organized respiratory chain with newly synthesized cytochrome c exists in the eggs.

**P4.3.-** HORMONAL CONTROL OF PRE- AND POST-ECDYSIAL TANNING IN  
**12** MANDUCA SEXTA.

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In larvae, pupae and adults of Manduca, sclerotization of the cuticle occurs both before and after ecdysis. Pre- and post-ecdysial tanning are both controlled hormonally but by separate mechanisms. The timing of pre-ecdysial tanning is determined by the withdrawal of the steroid hormone 20-hydroxyecdysone during the hours preceding ecdysis. This effect is apparently direct. Post-ecdysial tanning is subject to additional control by the peptide hormone bursicon, which is released massively into the blood as a single pulse either during ecdysis (larvae, pupae) or just afterwards (adults). Bursicon is not a single hormone. The tanning hormone released in larvae and pupae can be distinguished in bioassays from that released in adults, although the two hormones do cross-react in pupal and adult bioassays. The release sites of the pupal and adult hormones differ - in pupae bursicon is released from the CC/CA, whereas in adults it is released from the abdominal CNS.



**P4.3.-** ACETYLCHOLINESTERASE IN MESODERMAL ACCESSORY GLANDS OF MALE METARMORPHO-  
**13** SING TENEBRIO : ACTIVITY, LOCALIZATION AND MOLECULAR FORM.

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It has been discovered for the first time in the male mesodermal accessory glands of the genital apparatus of Tenebrio molitor a marked Acetylcholinesterase (AChE) activity from the newly ecdysed pupal to the mature adult stage, AChE activity is true cholinesterase (i.e. Acetylcholine hydrolase, E.C. 3.1.1.7) since it was inhibited by Eserine, BW 284 C51 but not by Iso-Ompa. AChE extracted from glands with 1% Triton and 1M NaCl sedimented as a single peak in sucrose density gradient with a 5.38 sedimentation coefficient. Activity per mg wet weight of gland rose at the mid pupal stage in correlation with the ecdysterone peak and then displayed a linear decrease. The rise of AChE activity per mg proteins exhibited a peak slightly earlier the ecdysterone peak but well correlated with the first bout of pupal gland mitosis. AChE activity was exclusively localized in the muscle coat of the spermatophore secreting gland.

**P4.3.-** MORPHOLOGICAL CHANGES ON THE REPRODUCTIVE SYSTEM OF THREE  
**14** INSECT SPECIES AFTER PRECOCENE II TREATMENT.

GARCERA-ZAMORANO, M.D.; T. MARTINEZ-CARRAU and R. MARTINEZ-PARDO.

Precocene II causes alterations in the reproduction of sensitive insect species. We have studied the disruptions of the female reproductive system of three species:

*Blattella germanica* (L), *Lygaeus militaris* (Fabr.), and *Onco-peltus fasciatus* (Dallas), which have shown different sensitivity, so far, to precocene treatment.

Newly emerged females (0 to 24 hrs. old) were treated topically with precocene II. *O. fasciatus* ones received a dosis of 10 µg/insect, whereas *B. germanica* and *L. militaris* received 100 µg/insect due to their higher resistance to the chemical. Controls received acetone only. All females were allowed to mate normally with young untreated males 48 hrs. after the treatment.

*B. germanica* were not affected by the treatment, their fecundity level was almost the same found in the control ones, and there were no appreciable alterations in their gonads at histological level.

**P4.4.-** FLUID AND ORGANIC SOLUTE UPTAKE IN COLLEMBOLA INFLUENCED BY  
**1** PH, TEMPERATURE, SALINITY AND DIFFERENT SIZE OF MOLECULES

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If Collembola are sufficiently dehydrated they absorb water from moist surfaces by coxal vesicles of ventral tube. As a rule a water deficit of about 20 % of the normal water content was to be found as an effective level. The highest uptake rates were taken for pure water. All rates were depressed by increased salinity of test solutions. Further the optimum range for the absorption is pH 5-6. At lower pH, e.g. pH 2, the rates decreased considerably. The animals seem to react acidophobic. Low temperatures also diminish the uptake, but in all cases, the absorption rates exceed water loss by transpiration. The net permeation of inulin, D-glucose, L-leucine, erythritol, glycerol and urea was measured, coupled with water influx. There is a correlation between molecular size and lipid solubility of test substances and the percent uptake rate. A nutritive function of the ventral tube seems not to be probable.

4

**P4.4.-** ON THE ALPINE NIVAL FAUNA: INVESTIGATION OF GLACIER AND  
**2** FIRN FLEAS, ISOTOMA SALTANS AND ISOTOMA NIVALIS (COLLEMBOLA)

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The nival fauna of two glaciers, ROTMOOS and GAISBERG, from the upper Ötztal-region near OBERGURGL/Austria, was investigated. One population of Collembola was found under stones connected to the ice surface of the glacier, the other we could observe on firn areas beside the glaciers but also on the under side of stones.

The first population seems to be the typical glacier flea, the other the firn flea. Structural differences will be shown by scanning electron microscopy completed by special details of some tissues. Furthermore data on the water balance are given: transpiration rates at different temperatures and humidities and the absorption of water at low temperatures.

Key words: microclimate, water balance, transpiration, absorption, ultrastructure

P4.4.-

3

## SHOOTING FOR HOST PLANT SELECTION IN APHIDS

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Aphids select their host plant by probing with their long thin piercing mouthparts. In contrast with most other insects, aphids lack external taste receptors on the mouthparts and presumably on their antennae and legs. Olfaction plays little if any role in host plant selection. Food acceptance is guided by an internal pharyngeal organ. The pathway of the stylets to the preferred tissue, the phloem, is mainly intercellular. Where then does the aphid perceive cues for host plant selection and which physiochemical processes are involved?

As a basic technique the electro penetration gram (EPG) is used, combined with radiofrequency microcautery for stylet cutting. The aphid, attached to a thin wire, and the plant are made part of an electrical circuit. As soon as the aphid penetrates the plant this circuit is closed. An amplifier then provides the EPG that can be recorded. At least six different patterns can be distinguished. A number of patterns and waveforms have been correlated with different penetration activities like saliva secretion and food uptake. Differences are demonstrated in EPG's from host- and non host plants, from susceptible and resistant crop plant selections. Histology, including EM, of the penetrated plant tissue after rapid stylet amputation allows correlation of the EPG with precise stylet tip location. Even on resistant plants the phloem is reached and exuded sap can be collected and analysed. Application of these techniques, however, may only contribute to the host selection theory when they meet a number of methodological requirements.

P4.4.-

4

EFFECT OF GLUCOSINOLATES ON THE DEVELOPMENT AND  
MULTIPLICATION OF Lipaphis erysimi (Kalt) (Homoptera; Aphididae)

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The crucifer crops are known to contain glucosinolates in abundance. The effect of glucosinolate extracts of Brassica campestris var. sarson (YS Pb 24), B. juncea var. raya (RLM-198) and Eruca sativa var. taramira (ITSA) was studied on Lipaphis erysimi under screen-house-at entomological research farm. It was observed that the total glucosinolate contents was negatively correlated with the feeding response, survival of nymphs and the various biological parameters, from 0.5 to 4.0 per cent of crude extracts. Taramira at 2 per cent, raya at 3% and sarson at 4% concentration were found to be at par with respect to its effect on the development of test aphid. The higher dosages (2 to 4%) of taramira glucosinolate suppressed the aphid population significantly more than the same concentrations of glucosinolate extracts of raya and sarson. Thus the glucosinolates of taramira were found to have more pronounced effect on the development and multiplication of the mustard aphid.

p4.4.-  
5

#### INSECTS AS A SOURCE OF PROTEINS IN THE FUTURE

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The endeavour to solve the problem of hunger and malnutrition is a vital task of our time. Entomophagy has been known for a long time, in many parts of the world.

In Mexico we know that the ancient cultures ate insects we have recorded 36 species in different codexs, and actually we have been recorded 119 species belonging to the different orders, the threat of a protein crisis hanging over the world, the search for new food sources goes on. The insects could be a source of proteins in the future, their protein content in dry basis goes from 9.45 % 81.65% in Hymenoptera, 52.13% to 77.13 in Orthoptera, 36.82% to 71.52% in Hemiptera, 20.91% to 69.05 in Coleoptera, 35.90% to 76.94% in Diptera, 34.34 % to 71.60% in Lepidoptera and 32.73% to 72.02% in Homoptera. The protein quality gave by the chemical score goes from 10% until 96%, having most of them 50% to 70%.

p4.4.-  
6

#### FREEZING TOLERANCE IN ARCTIC INSECTS

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FREEZING TOLERANCE is a common strategy for the overwintering survival of many arctic insects. However, as arctic research progresses and the body of information on insect cold tolerance mechanisms grows, the number of discrepancies among individual species increases. This paper presents similarities as well as anomalies in the abilities of different species to prevent water loss, synthesize various cryoprotective substances, and survive freezing. Particular attention is devoted to the role of nucleating agents in the freezing tolerance of arctic beetles. The variations in cold tolerance mechanisms that are elucidated indicate that strategies for survival of low winter temperatures have evolved independently in many different insects.

**P4.4-7** PERIODIC FLUCTUATIONS IN THE LEVEL OF FREE SUGAR IN THE  
HEMOLYMPH OF STARVED LARVAE AND ADULTS OF *TENEbrio MOLITOR*

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During fifteen days' starvation the hemolymph of larvae and adult males and females of *T. molitor* was studied for variations in free sugar (FS) composition. Periodic fluctuations in FS level in the hemolymph at both stages were shown not to be a result of variations in its volume. Over the studied period no variations were observed in hemolymph specific gravity and total solids, either. Out of the sugars identified in the hemolymph of larvae and imago, fructose, glucose, maltose and glucosamine tend to be exhausted at a rapid rate during the first week of starvation. The resulting fluctuations in FS concentration at both stages are largely due to changes in the amount of trehalose. Besides, they are related to changes in glycogen contents of the fat body and muscles. Importance of these fluctuations and mechanism for their occurrence are discussed.

**P4.4-8** DEVELOPMENTAL CHANGES IN THE HAEMOLYMPH DURING THE LAST  
LARVAL INSTAR OF *SPODOPTERA EXIQUA*

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A continuous increase in the solid concentration occurs in the haemolymph throughout the last, i.e. 5th, instar of *S. exiqua* larvae. The rate of increase is slow in caterpillars over their feeding period, whereas it is rapid in the prepupal stage. Similar changes can be observed in the concentration of proteins, free sugars and lipids in that tissue. A substantial increase in the solid concentration in the prepupal haemolymph is largely due to its dehydration. Thus, the volume of haemolymph in that developmental stage decreases rapidly, whereas its specific gravity increases. The total protein, free sugar and lipid content of the whole haemolymph in prepupae is considerably lower than that in feeding fully-grown caterpillars.

P4.4.-  
9 AMINO ACID REQUIREMENTS OF TWO BIOTYPES OF THE PEA APHID  
ACYRTHOSIPHON PISUM (HARRIS)

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Out of ten amino acids deleted individually from a chemically defined diet fed to two biotypes (C and J) of the pea aphid, Acyrtosiphon pisum (Harris), seven amino acids viz., arginine, histidine, methionine, lysine, phenylalanine, threonine and tryptophane were essential for growth and/or reproduction of biotype C, but only four viz., histidine, methionine, threonine and valine were essential for biotype J. Although not essential, leucine was slightly beneficial for growth and/or reproduction of biotype C, and arginine and isoleucine were beneficial for biotype J. This appears to be a rare example of two insect populations within one species differing in their amino acid requirements.

P4.5.-  
1 FLIGHT BEHAVIOUR OF THE WATER BEETLE DYTISCUS  
MARGINALIS L. (DYTISCIDAE, COLEOPTERA).

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Imaginal beetles (males and females) were caught in the field or cultured in the laboratory. During flight on a balance in front of a wind tunnel, the elytra are held in a horizontal posture. The frequency of potentials recorded from the asynchronous wing muscles of the metathorax decreases with flight duration and increases with increasing speed of frontal air current. Parameters reach a peak during the first few minutes of flight. Following 20 min of flight, the stroke angle of the wings is about  $160^{\circ}$ , the wing-beat frequency 40 Hz, the lift only 50% of the body weight, and the 'flight speed' ('thrust-compensated flight') more than 3 m/s. The antennae are stretched forward during flight. When the flagella are removed, lift increases and flight speed decreases, without changes in the other parameters measured.

**P4.5.-** VISUALLY-INDUCED FLIGHT BEHAVIOUR IN THE TETHERED  
**2** LOCUST, SCHISTOCERCA GREGARIA.

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The behaviour of flying locusts in relation to lateral visual stimuli has been studied. Tethered locusts flew in front of a wind tunnel on three different measuring devices. Wing-beat frequency, flight speed, lift, and horizontal force, or torque about the vertical body axis, or yaw could be measured. Change of illuminance (150 to 1 lux) stimulates flight significantly, i.e. most flight parameters measured are enhanced. Lift is increased to a value equal to body weight, whereas at constant illuminance it is only about 75%. Changing lateral illuminance induces torque reactions towards the brighter screen (positive phototaxis). Unilateral or bilateral movement of a vertical-stripe pattern generates yaw-torque which results in a turn in the direction of the stripe pattern movement.

**P4.5.-** CONTROL OF ANTENNAL MOVEMENTS IN TETHERED FLYING LOCUSTS  
**3** (SCHISTOCERCA GREGARIA).

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The antennae of locusts are air-current sense organs. During flight the antennal position in the horizontal is controlled via a negative feedback mechanism. In this mechanism the two antagonistic muscles of the scapus function as the effectors. Each muscle is innervated by at least three motoneurons. Sudden air-current stimuli induce synchronous phasic-tonic responses in the myograms of both muscles. After start of flight the impuls-rate of the median muscle remains high, and that of the lateral muscle decreases to approximately half the level of the median muscle. The position of the pedicellus is held constant by the balance of the aerodynamic forces and of the forces between the two muscles. The stiffness of the scapus-pedicellus joint is adjusted by the level of muscle activity. Two feedback-circuits, a fast proportional-differential (PD) and a slow proportional-integrational (PI) circuit control the pedicellus position. The sense organs of the PD-circuit measure exclusively the position of the scapus-pedicellus joint, and those of the PI-circuit predominantly that of the pedicellus-flagellum joint.

**P4.5.-**  
**4** CONTROL OF BODY HEIGHT IN THE WALKING STICK INSECT

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A hairplate on the trochanter of the stick insect, *Carausius morosus*, is the position transducer of a feedback system controlling the position of the coxa-trochanteral joint (Wendler, 1964). This feedback loop is important in regulating body height in the standing and walking animal. The present work begins with a description of the force exerted by the leg in response to sinusoidal movement of the joint. The results are then compared with the step response measured both in standing and walking animals. During walking the gain and time constant of the system are reduced. These changes are interpreted as adaptations to walking.

**P4.5.-**  
**5** THE ROLE OF A FAST WING REFLEX IN THE LOCUST FLIGHT SYSTEM

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In the quiescent locust, mechanical or electrical stimulation of the campaniform sensilla on costa and subcosta of the forewing elicit a contraction of the wing depressor muscles of all forewings. Repetitive stimuli up to more than 20 Hz (flight frequency) are effective in a 1:1 manner.

In the flying locust, the flight rhythm can be entrained by such rhythmic stimulation. Single stimuli cause a distinct reset. Thus, taking also into account, that the wing receptors respond to wing bending during flight, these receptors turn out to be an integral part of the locust flight oscillator



**P4.5.-** THE ESCAPE REACTION OF ACHETA DOMESTICA UNDER OPEN-LOOP  
**6** CONDITIONS

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House crickets were allowed to run on a paired tread wheel. In this situation, the animals are tethered, and the three legs of each side can independently turn a wheel of 14,3 cm diameter. The movements of the two wheels are recorded and then processed in a PDP 11-40 computer.

As in freely walking crickets, the walk shows bouts of progression interrupted by short stops. Oscillations within the bouts are caused by the tripod gait. Left and right side are often in phase, but sometimes show antiphase or even different frequencies.

Air pulse stimulation of the cerci causes a higher walking speed. If the air pulses are delivered at different angles from the side, the cricket tries to turn away by moving the wheels with different speeds. The characteristics of this response are described in detail.

**P4.5.-** WALKING, SWIMMING AND INTERMEDIATE LOCOMOTION IN NEPA RUBRA  
**7**

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On land, Nepa walks in a triplet-coordination, in which contralateral legs alternate. Swimming is produced by the middle and hindlegs alone. In this situation contralateral legs move in the same phase.

We describe all relevant parameters of the leg movements under both conditions. An intermediate coordination can be produced by variations of the external conditions. This means that the actual coordination is determined by receptors measuring under-ground properties.

**P4.6.-**  
**1** Age-dependent occurrence of ascending axons on omega neurons  
in the female cricket Teleogryllus oceanicus

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The omega neurons are a mirror-symmetrical pair of prothoracic auditory interneurons of crickets, which have been previously described as intraganglionic. We have studied the omega neurons of Teleogryllus oceanicus with intracellular recording and staining techniques (Lucifer Yellow,  $\text{NiCl}_2$ ) and have found that many omega cells have axons which project out of the prothoracic ganglion. The occurrence of these axons is age dependent. Seventy-five percent of omega neurons stained in females 1 to 14 days after the imaginal molt had this axon while only 30% of those stained in females 33 to 42 days after the imaginal molt had an ascending axon.

The ascending axon arises contralaterally to the soma at the most anteriolateral bend of the otherwise "classical" omega neuron and travels up the neck connective in a position different from the axons of other identified ascending auditory interneurons.

Anteriorly projecting omega neurons are developmental variants of the "classical" omega neuron and do not represent a separate neuron type. Responses to frequencies from 3.5 kHz to 60 kHz are not distinguishable for the two morphological types. Furthermore, we have never stained both a "classical" and an ascending omega neuron with the same laterality (i.e. both left or both right) in a single animal, despite 12 attempts to do so, though we have frequently stained both left and right omega neurons.

**P4.6.-**  
**2** ON THE CENTRAL NERVOUS BASIS OF SOUND PRODUCTION IN GOMPHOCERINE GRASSHOPPERS

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Orthopteran insects such as gomphocerine grasshoppers are known for their highly developed acoustic communication. The neuronal mechanisms underlying this behaviour are investigated using two methods:

- (1) In freely moving, normally stridulating animals the central nervous output pattern is recorded indirectly via flexible wire electrodes inserted into the thoracic muscles. Thus, stridulation can be described in terms of moto-neuronal events.
- (2) Using brain lesion techniques long lasting and normally patterned stridulation can be released in tethered animals partly dissected for micro-electrode application. Intracellular recordings from the interganglionic connectives have revealed a complex intersegmental control system mediating song specific information between the brain and the thoracic ganglia.

P4.6.-  
3

ON THE LONG-TERM SENSORY CONTROL OF STRIDULATION IN THE GRASSHOPPER  
CHORTHIPPUS BIGUTTULUS

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Orthopteran stridulation has long been regarded as being predominantly centrally programmed. Sensory feedback, although undoubtedly existing, was thought to be of minor influence since ablation experiments seemed not to change the stridulatory motor patterns. However, this has not proved true in the *long* term: if the hindleg nerve no. 5B1 is severed on both sides the stridulatory pattern changes gradually during the ensuing days. For example, the bilateral co-ordination is affected and the pauses subdividing the song sequences disappear. It has been shown that the loss of cordotonal-organ located in the tip of the hind-femora is responsible for this long-term affect.

P4.6.-  
4

SPATIAL DISPERSION AND AGONISTIC CONTACTS OF MALE BUSHCRICKETS IN THE  
BIOTOPE

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The acoustic behaviour of the bushcricket *Tettigonia cantans* has been investigated in different natural habitats. Constantly singing males clump in areas with dense vegetation and within these clumps they are regularly spaced. Males seem to space themselves according to the song intensities (72-87 dB SPL) they receive from each other. Between close neighbours rivalry behaviour is expressed either by males producing alternating songs, or in an approach towards a constantly singing insect, or in an aggressive encounter. Of these three behaviour patterns aggressive encounters are most common in high-density populations.

**P4.6.-** SIGNIFICANT PARAMETERS IN THE CONSPECIFIC SIGNALS FOR PROCESSING IN  
**5** VIBRATORY-AUDITORY NEURONS

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The auditory-vibratory neurons of locusts and tettigoniids were tested with simulated natural sound and vibration signals. The stimuli were synthesized according to the time- and frequency parameters of the conspecific song and vibration using a microcomputer. This provides the possibility to use well defined parts of the power-spectra and other time parameters as well. Using this method we were able to reveal significant parameters of the natural conspecific song and vibration for optimal signal-processing in the vibratory-auditory neurons of the ventral nerve cord.

4

**P4.7.-** THE MOCKING BUG PHYMATA CRASSIPES  
**1**

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Ambush bugs *Phymata crassipes* imitate the duration of acoustic or vibrational stimuli with their alternation signals. In our experiments the animals were stimulated with sound pulses (400 Hz, square wave), ranging from 0.05 to 1.3 s and the responses were measured. It was found, that the duration of responses is related to the logarithm of stimulus duration. We found out that essentially only one parameter is needed for description of responses, namely the response to a stimulus of predefined length (e.g. 1 s). The set of response curves converges to one point, not far from the value for intraspecific alternation. In some experiments, there was another set of values, without a continuity with the main set of responses, mainly as an answer to longer stimuli. A latency of responses is negatively correlated to the logarithm of stimulus duration. The possible explanation for this unusual mocking behaviour of *Phymata* bugs could be in attraction of some insects, their potential prey, by imitation of their vibrational songs.

**P4.7.-**  
**2** CURRENT-SOURCE-DENSITY (CSD) ANALYSIS OF THE SENSO-MOTOR-TRANSITION  
OF VIBRO-ACOUSTIC SIGNALS IN THE CNS OF LOCUSTA MIGRATORIA

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The real-time three-dimensional Current-Source-Density analysis was applicated to the motor synaptic regions in the three thoracic ganglia of *Locusta migratoria*. A seven-electrode matrix was used for simultaneous recordings of acoustically and vibratorially evoked field potentials. By means of these the CSD was computed "on-line". This CSD-method allows - in contrast to simple field potential analysis - a direct identification and localization of current-sources (-sinks), which actually indicate neuronal active sites within the investigated nervous tissue. At least three kinds of vibratory and acoustic transition could be seperated:

1. direct inputs from vibratory receptors of the ipsilateral segmental leg
2. inputs via interneurons in the ventral cord from the other five legs and from bimodal vibro-acoustic neurons ascending to the brain
3. descending inputs coming from the head ganglia.

**P4.8.-**  
**1** LIGHT DEPENDENCE OF METABOLIC RATE AND ADAPTATION IN DIPTERAN  
COMPOUND EYES.

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In fly photoreceptor cells substantial visual pigment conversions activate both metabolism and pupil mechanism. We studied these processes by microspectrofluorometry in vivo. The blue-induced green fluorescence of mitochondrial pigments, notably flavoproteins, was measured in white eyed mutants (blowfly *Calliphora erythrocephala* mutant chalky and housefly *Musca domestica* mutant white). Intense illumination of a dark adapted eye induces an increase, in 1 s, of 15-30% of the green autofluorescence of the eye, which is followed by a decrease lasting a few seconds. Pupillary activity was investigated in wild type flies by monitoring its absorbing effects on the blue-induced red fluorescence from the visual pigment in the rhabdomeres; this process occurs in a few seconds.

The intensity ranges for metabolic activity and pupil closure correspond strikingly. The action spectra are very similar to the absorption spectrum of fly rhodopsin. After saturating light both systems dark adapt with a nearly identical time course. Metabolic activity is inhibited by hypoxia whereas the pupil is closed, independent of illumination.

We conclude that metabolism and pupil mechanism are intimately connected constituents of fly photoreceptors, which extend their dynamic working range.

P4.8.-  
2 VISUAL RESPONSES OF THE PHOTORECEPTORS IN THE FLY  
(Calliphora) MEASURED IN VARIOUS TEMPERATURES.

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Intracellular depolarizing responses from photoreceptor cells to a flash light stimulation from a point source were studied at temperature range of +30 C to +5 C. The intensity functions (V-log I) and the spectral sensitivity functions were analyzed by a digital computer (PDP 11/10) and examined at various temperatures. The intensity responses to single stimuli showed slowing down of the time course, reduction of the amplitude and increase of the latency in function of decreasing temperature. The double-peaked (350 nm and 490 nm) spectral sensitivity showed similar changes in wave form of single responses, but the 350 nm peak was significantly less sensitive to temperature decrease than the 490 nm peak. This finding indicates a possibility of two parallel membrane active reactions in the same receptor cell.

P4.8.-  
3 Representation Of Optokinetic Signals In The Thoracic  
Connectives Of The Stick Insect - *Carausius Morosus* -  
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When a stick insect turns in reaction to a rotating striped pattern the leg movements change in a characteristic way. In tethered animals there is a corresponding modulation of the spontaneous activity of motoaxons in the protractor nerve to the middle leg.

This reaction may be caused by a set of interneurons in the neck and thoracic connectives. Their spontaneous activity is modulated by variations of the pattern velocity. The properties of this set of interneurons are presented in detail.

**P4.8.-** STRUCTURE OF ARCTIID OCELLI (*Cretonotos transiens*) AND  
**4** INFLUENCE ON THE BEGINNING OF ACTIVITY IN THE EVENING

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The Asian tiger-moth Cretonotos shows an activity period of 2-3 hs after nightfall (running, flying, inflating large male coremata, luring by males and females, mating) which is accompanied by an oxygen consumption 10-20 times more than during the remaining time of resting. By use of a closed O<sub>2</sub>-measuring system and of experimentally altered light cycles, and by comparing moths with lacked ocelli with controls under these conditions, it can be shown quantitatively that the 2 ocelli are the most important trigger for the exact starting of the activity period and the interconnected activity phases of males and females, reacting to light intensity and -decrease with time. The fine structure of the ocellar photoreceptors changes with adaptation level, revealing huge rhabdomeres in the darkness, but only small rhabdomeres with many degradation states of photoreceptive membranes in the light.

**P4.8.-** THE BEHAVIORAL PHYSIOLOGY OF THE ESCAPE RESPONSE  
**5** OF TIGER BEETLE LARVAE (CICINDELA)

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The tiger beetle larva (Cicindela) is a burrow-dwelling ambush predator which withdraws into its burrow with the passing of large objects. Predation and escape are mediated primarily by vision, though mechanical stimuli also elicit both behaviors. Laboratory experiments confirmed that the necessary visual stimulus for elicitation of escape is true image movement: receding, looming, or transverse. Low frequency flicker or whole field dimming are not sufficient. Further, movement of images with multiple texture elements (such as checkerboards) do not elicit the response even when the elements are much larger than the system's minimum spatial resolution (2-5° depending upon figure contrast). When a figure is moved in phase with a textured ground escape is inhibited. However, when the figure and the ground move in antiphase the response is strong. Thus, it appears as though the processing mechanism functions to detect and direct a response to moving objects of a suprathreshold size. Typical of other escape responses, this one habituates quickly and experiments with both visual and mechanosensory stimuli show that habituation is not transferred across sensory modalities.

The response can be mediated by any one of the 4 principal stemmata. Neuroanatomical studies have supported this by revealing a complex optic lobe consisting of at least two synaptic neuropiles below each stemma. Further, there is a pair of giant fibers located mid-dorsally in the ventral nerve cord which may mediate the rapid escape response.

P4.8.-  
6

PHOTOPERIOD EFFECT ON LIPID PATTERN IN FEMALES OF THE APHID  
MEGOURA VICIAE BUCKTON

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The polar lipid pattern has been comparatively studied on three categories of females from the same strain: (A) viviparae apterae from a stock culture constantly kept under long daily photoperiods (16h light/day), (B) viviparae apterae transferred to short photoperiods (8h light/day) at 6 days prior to birth and (C) oviparae. Total lipids were extracted with chloroform/methanol 2/1 and partitioned against 0.88% KCl. TLC separation showed phosphatidylethanolamine, sulfolipids (3.16\*(A), 5.00\*(B), 2.28\*(C)), phosphatidylcholine and no spots of cholesterol. Aqueous phases were tested for sialic acid (absent) and muramic acid, present in different amounts (14.6\*(A), 5.3\*(B), 14.3\*(C)). Qualitative and quantitative differences were found not only between A, B/C, viviparous/oviparous groups, but also between A/B viviparous groups reared under different photoperiods.

\* Values reported as µg/mg dry weight

P4.9-  
1

ROLE OF THE GASTRIC CAECUM AND THE ANAL CANAL IN THE OSMOREGULATION OF LARVAE OF THE SEAWATER MOSQUITO, Aedes togoi THEOBALD

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Our knowledge on the process of hyposmotic regulation in salt-water insects is scanty. Larvae of the seawater mosquito, Aedes togoi Theobald, are excellent hyposmotic regulators maintaining their hemolymph osmolarity at about one-third the level of seawater. In seawater, they drink copiously in order to compensate for the inevitable loss of body water by osmosis across the body surface and excretion of urine. Swallowed seawater is stored in the gastric caeca for a while before reaching the midgut. A strongly positive reaction of the caecal epithelium of seawater larvae to the histochemical assay for chloride ions suggests that the gastric caecum of larvae in seawater 'dilutes' or 'desalts' the ingested seawater by absorbing salts, thus facilitating the absorption of ion and water in the midgut. On the other hand, elimination of excess salts from the body seems to be essential to the hypo-regulation of salt-water insects. The anal canal, the terminal portion of the hindgut, is shown to be a salt-excreting organ in A. togoi larvae in seawater. This organ is considered to have great importance in the osmoregulation of the larva by regulating the active excretion of excess salts in response to different environmental salinities.



P4.9.-  
2

THE PATTERN OF OSMOREGULATION IN LARVAE OF THE MOSQUITO CULISETA  
INORNATA

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Previously, two patterns of osmoregulation have been described for larval mosquitoes; one for freshwater species, the other for saline-water ones. Both groups of mosquitoes hyper-regulate their hemolymph osmotic and ionic concentrations in dilute media (less than 400 mOsm). Saline-water Aedine larvae are additionally capable of hyper-regulation in more saline waters. We have examined the pattern of osmoregulation in Culiseta inornata, a species inhabiting brackish coastal and inland waters. C. inornata can survive and develop in mixtures of distilled and seawater ranging from 0-700 mOsm (0-70% seawater). In media below 400 mOsm, the larvae are hyper-regulators with regard to hemolymph osmotic and ionic concentrations. In media more concentrated than 400 mOsm, the larvae osmoconform with regard to hemolymph osmotic concentration. In these same larvae, however, hemolymph sodium, chloride and potassium concentrations are closely regulated. Since the osmotic concentration of the major hemolymph ions cannot account for the total osmotic concentration of the hemolymph, these data suggest that larvae of C. inornata sequester some organic osmolyte to offset water loss to the environment. This pattern of osmoregulation is distinct from that of previously described freshwater or saline-water mosquito larvae. We propose the term brackish-water mosquito larvae for species exhibiting this pattern of osmoregulation.

P4.9.-  
3

PHOTOPERIODISM AND SEASONAL DEVELOPMENT OF THE PITCHER-PLANT  
MOSQUITO, WYEOMYIA SMITHII (COQ.)

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Wyeomyia smithii overwinter as larvae in the water-filled leaves of the purple pitcher plant, Sarracenia purpurea, from the Gulf of Mexico to Canada in eastern North America. The onset, maintenance, and termination of diapause are mediated by photoperiod. To model vernal development, we first examined the developmental response of wild-caught, diapausing larvae to constant and fluctuating daily temperatures and to static and gradually increasing photophases. Second, we simulated light and temperature conditions in leaves by (1) comparing action spectra of photoperiodic response with light availability spectra in leaves and (2) correlating mean and amplitude of daily leaf temperatures with nearby weather station temperatures. Third, we combined larval responses with simulated leaf environments to predict development. The model produced predictions whose 95% confidence limits entirely bracketed actual development in nature. When used to simulate development over a wide geographic area, the model generated two important predictions. First, temperature, not photoperiod, has the major, determining effect on the timing of vernal development. Second, the timing and variability of vernal development reflects mainly local temperature and not adaptive (genetic) differences among geographic populations. (Supported by NSF Grant DEB-7822799)

P4.9.-  
4

#### BLOOD MEAL CONCENTRATION AND FECUNDITY IN ANOPHELES

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Females of various Anopheline species represent the principle vectors of primate malaria. Each blood meal contributes the protein material required for oogenesis in a positive correlation; under appropriate conditions it also can be the occasion of an infection of the host. Fecundity of female Anopheles was studied in 3 species and compared to the yellow fever mosquito Aedes aegypti. Although Anopheles generally is of larger body size than Ae. aegypti, its distensible part of the midgut -the so-called stomach- is significantly smaller because less blood is retained. Yet the number of eggs matured per female is similar to Aedes aegypti.

An. stephensi is known to release "red urine" during engorging, while the other species tested produced "clear" urine. This phenomenon led us to compare quantitatively the total nitrogen, the hemoglobin, and the weight of the blood ingested with the blood content of the midgut in newly fed females and in the pooled urine. A mechanism to increase fecundity by blood meal concentration is suggested because more blood is ingested than is found in the stomach. The protein is concentrated by a factor of two at least, the rest of the meal being excreted as a dilute solution, the red or clear urine respectively.

As a behavioral adaptation, compensating the smaller volume of blood meals, Anopheles avidly refeed within 24 hours, in contrast to Aedes with their humoral inhibition of host-seeking during gonotrophic cycles.

P4.9.-  
5

#### GENETIC POLYMORPHISM IN THE DYNAMICS OF GONOTROPHIC CYCLES IN Aedes Aegypti

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In female mosquitoes, ingestion of blood initiates a gonotrophic cycle. More specifically, it activates the endocrine control system (within 1 hour), it induces the production and secretion of proteolytic enzymes (within the first few hours), it stimulates the process of urination (within a few minutes), and through additional endocrine signals vitellogenesis is activated, parallel to excretory processes.

Quantitative analysis of the excretory processes at short intervals during the whole period of blood digestion and catabolism (48 hours) in Aedes aegypti revealed three distinct phenotypes in a given population: "early, late, and intermediate" females. They are distinguished by the time of hematin defecation in relation to uric acid excretion. The peak of hematin extrusion occurs before 34 hours (early), between 34-40 hours (intermediate), or later. So far, nine strains of Ae. aegypti of different geographic origin have been screened with respect to the frequency of these three phenotypes; newly isolated strains (3-4 generations in the laboratory) as well as old colonies (55 years in the laboratory) exhibited always a more or less Mendelian distribution. A similar pattern was obtained by crossing early x late phenotypes. In addition, selection experiments, still underway, led to an increase in expression of up to 80-90% of the early phenotype.

P4.9.-  
6

ULTRASTRUCTURE OF THE CARDIACAL NEUROSECRETORY SYSTEM OF ADULT  
AEDES AEGYPTI

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Discrete corpora cardiaca, consisting of neurosecretory axons, neurohaemal sites, intrinsic neurosecretory cells, and glial cells are not found in mosquitoes.

Cells homologous with the intrinsic neurosecretory cells of other insects are located in the thorax of mosquitoes, associated with the corpora allata. These cells are named cardiacal neurosecretory cells. Axons run forwards from the cardiacal neurosecretory cells into the allatal nerves.

Neurosecretory release sites occur over virtually the whole of the nervi corporis cardiaci, allatal and oesophageal nerves so that these nerves constitute a very extensive neurohaemal organ for the brain neurosecretory cells. This is named the cardiacal neurohaemal organ.

Neurosecretory release sites occur on the perikarya of the cardiacal neurosecretory cells and on their axons where they enter the allatal nerves.

P4.9.-  
7

CORRELATION OF HOST-SEEKING BEHAVIOR, LACTIC ACID-RECEPTOR SENSITIVITY  
AND OVARIAN DEVELOPMENT FOLLOWING A BLOOD MEAL IN THE MOSQUITO, AEDES  
AEGYPTI

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Host-seeking behavior of female mosquitoes has been shown to be inhibited following a blood meal that is initially due to abdominal distension and later (30 to 72 hr) due to a transfusible hemolymph-borne factor. The later phase of behavioral inhibition is dependent on the presence of the ovaries for the first 8 to 12 hr following the blood meal. The sensitivity of the lactic acid-receptor has been shown to be depressed beginning about 30 hr following a blood meal and is also due to a transfusible hemolymph-borne factor.

We now demonstrate a 1:1 correlation between the sensitivity of the lactic acid-receptor and the stage of ovarian development following a blood meal and a 1:1 correlation between low lactic acid-sensitivity and the absence of host-seeking behavior. In females having follicles at stages 1 or 2, lactic acid-receptor sensitivity is high and host-seeking behavior is observed. In contrast, females in which the follicles have initiated development to stage 3 and beyond always have low lactic acid-sensitivity, and host-seeking behavior is absent. Thus, there appears to be a potential causal relationship in which the ovaries release or cause to be released a hemolymph-borne factor that acts on the lactic acid-receptors to depress their sensitivity to the host-attractant, lactic acid, and thereby, inhibit host-seeking behavior.

**P4.9.-** DNA SYNTHESSES IN THE FAT BODY NUCLEI AFTER HORMONAL  
**8** APPLICATION ON ISOLATED ABDOMENS OF Aedes ägypti.

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In the mosquito, Aedes ägypti, the fat body nuclei of the last larval stage show a diploid DNA content. During the development of the imago the fat body nuclei undergo several ploidisation steps of their genome. These DNA replications take place in two different<sup>1</sup> cycles. Each of them is under control of juvenile hormone (JH III).

The first replication cycle starts shortly after the adult moult and lasts until the first blood meal (72 hours after emergence). The polyploidisations result in 4n and 8n fat body nuclei, with relative frequencies of 80% and 20% respectively.

Until 36 h after the blood meal no further DNA replications can be observed. During this period the JH titer is very low, too. Subsequently the JH III titer rises again and the 8n fat body nuclei obtain a relative frequency of 60%.

We examined the effects of the juvenile hormone analog methoprene (ZR-515) and of JH III on ploidy levels during the first 72 hours after emergence.

The abdomens were isolated by ligating and topically applied with ZR-515 or JH III. After Feulgen staining of the fat body nuclei the DNA content was determined by microspectrophotometry.

**P4.9.-**  
**9** JUVENILE HORMONE LEVELS IN THE ADULT FEMALE MOSQUITO Aedes Aegypti

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The role of juvenile hormone (JH) in reproduction of the adult female mosquito has been described as preparing the mosquito for the blood meal. However there is some evidence that JH might also be important after the blood meal. To examine this question we measured the levels of JH during the life of the adult female using a coupled gas chromatography-mass spectral technique. We previously showed that JH III is the only form present in Aedes aegypti (Baker et al. 1983, J. Insect Physiology 29:465-470). Levels of JH rose for 2 days after emergence to a maximum of 20 pg/female. They then gradually fell over the next 5 days. If the female is fed a blood meal 3 days after emergence, JH levels fell rapidly to about 3.2 pg/female by 3h, and then rose again 48 hours after the blood meal.

These data fit in well with previous experiments suggesting that JH prepares the mosquito physiologically and behaviorally for the blood meal. The rapid decline after a blood meal occurs just before ecdysteroid levels increase. The second rise 2 days after a blood meal presumably prepares the animal for the second blood meal.

P4.9.-  
10

## CYTOLOGICAL AND BIOCHEMICAL ASPECTS OF BLOOD DIGESTION IN MOSQUITOES

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Female mosquitoes which need blood for egg maturation play an important role in transmitting malaria and other parasites. Digestive processes may influence the parasite's development in the midgut. Bloodmeals trigger various processes in mosquitoes. Morphometrically assessed dynamics of the midgut epithelial cells can be correlated with the release of digestive proteases in Aedes aegypti and in Anopheles stephensi. During digestion, the rough endoplasmic reticulum proliferates, the ratio of membrane-bound to free ribosomes increases, and active proteases are synthesized and released into the gut lumen. Augmentation of the cellular volume enhances the functional capacity of the midgut.

Peritrophic membranes (pm) which are formed by the stomach upon a blood-meal contain N-acetylglucosamine in A. aegypti and N-acetylgalactosamine in An. stephensi. In An. stephensi the formation of the pm is correlated with exocytosis of apical cytoplasmic granules, and the solubility of the pm depends on salt concentration (mainly calcium) in the gut lumen. The role of the pm remains speculative.

By using autoradiographic labelling it can be shown that products of blood digestion are mainly absorbed in the posterior part of the midgut in An. stephensi.

P4.9.-  
11

## THE BRAIN OF ADULT Aedes aegypti

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A general description of the brain and a detailed account of the deutocerebrum of adult female Aedes aegypti (L.), based primarily on silver stained semithin (0.5  $\mu$ m) serial sections, is presented.

The total average volume of the brain is  $0.11\text{mm}^3$ , of which the cell body rind constitutes 36.1%. Eleven distinct regions of the cell body rind can be distinguished including two cell types. Internally the major regions of the supraoesophageal ganglion are the visual lobes, central body, mushroom bodies, deutocerebrum, tritocerebrum, and the nerve tracts connecting these to each other and the suboesophageal ganglion.

The deutocerebrum consists of the glomerular (antennal) lobes, aglomerular (mechano-sensory) regions, an "accessory lobe", and the commissural and nerve tracts that link these to each other, to the mushroom bodies, and to the suboesophageal ganglion.

P4.9.-  
12

EXAMINATIONS ON EGG DIAPAUSE IN Aedes albopictus IN JAPAN AND  
SOUTHEAST ASIA AT SHORT DAYLENGTH

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The mosquito, Aedes albopictus, distributed from Southeast Asia to the northern part of Honshu Island of Japan. Egg hatchabilities in geographically varoed strains of Ae. albopictus in Japan and Southeast Asia were examined using eggs laid from females reared as adults at a temperature of 21 C and short daylength of 10 hr. In the strains of southern part of Japan such as Amami-Oshim and Southeast Asia, many eggs were found to have hatched, on the other hand eggs of strains of Kyushu and northward scarcely hatched. This implies that diapausing eggs of Ae. albopictus appear at short daylength in autumn, and that this mosquito usually overwinters in the developmental stage of diapausing eggs in Japan lying in the northern part of Kyushu.

4

P4.9.- EFFECTS OF TEMPERATURES ON REPRODUCTIVE ACTIVITY OF  
13 Culex pipiens COMPLEX IN JAPAN

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In Japan, the mosquitoes of Culex pipiens complex are composed of the following three members, Culex pipiens molestus, Culex pipiens pallens, Culex pipiens quinquefasciatus. Cx. p. molestus is distributed together with Cx. p. pallens in the parts of Japan lying north of Kagoshima, but not in more southern parts, such as Okinawa, in which Cx. p. quinquefasciatus is found. To make clear the factors limiting the distribution of Culex pipiens complex in Japan, insemination and egg-hatching were examined with eggs as well as the females of Cx. p. molestus, Cx. p. pallens and Cx. p. quinquefasciatus at high temperatures. In Cx. p. molestus and Cx. p. quinquefasciatus, females usually inseminated. Egg-hatchability of Cx. p. quinquefasciatus was high, but eggs of Cx. p. molestus scarcely hatched. In Cx. p. pallens, females did not inseminate commonly. Thus, high temperatures seem to play a role as an important factor limiting the distribution of Culex pipiens complex in Japan.

**P4.9.-**  
**14** PURIFICATION OF THE EGG DEVELOPMENT NEUROSECRETORY HORMONE AND ITS  
EFFECTS IN VIVO

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The egg development neurosecretory hormone (EDNH) stimulates the ovary of Aedes aegypti to produce ecdysone. We have developed improved methods for purification of this hormone using high pressure liquid chromatography. We have also examined the effect of injected EDNH on ecdysteroid and vitellin levels in non-blood-fed females. These experiments have indicated the presence of several forms of EDNH which may represent precursors and metabolites.

**P4.9.-**  
**15** FATE OF NITROGENOUS SUBSTANCES STORED IN THE MOSQUITO CROP

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A protein food such as AMP-containing egg albumin stored in the crop quite often activates oogenesis of female mosquitoes as blood meals do. However, when the same protein food is introduced to the crop it is soon excreted without utilization and oogenesis is not activated. From many authors' studies, it seems certain that the amount of protein transferred from the crop to the midgut is not enough to induce proteinase secretion. However, even amino acids, which do not require proteinase, are often eliminated when introduced into the crop. This agrees well with their behaviour in nature where they fill their crops with nectar but seldom with nitrogenous substances. Nonetheless, observations of these females which could utilize amino acids, or less frequently protein in the crop, suggest that they have some ability to regulate digestion of crop-stored nutrients other than sugar which is well regulated in many insects. These females retained the food much longer than those which eliminated it. Since females decapitated immediately after crop-feeding failed to retain the food and rapidly emptied their crops, this regulation seems to be under the control of the brain.

Section 5    **Biochemistry** .....

  R 5.1.    *Metabolism of Insects* .....

  R 5.2.    *Sterols, Parasites* .....

  S 5.1.    *Insect Hormones* .....

  P 5.       .....



## **R5.1.** ENERGY METABOLISM IN INSECT FLIGHT MUSCLES -

**1**

### REGULATION OF SUBSTRATE TRANSPORT AND INTERMEDIATE METABOLISM

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The flight muscles of many insect species have the highest capacity and intensity of the intermediate metabolism in animal tissues. When these insects start to fly, substrate oxidation in the flight muscles increases by more than one hundred times. Such an enormous increase of the energy production requires two different things: 1. Substrate release from storage sites and substrate transport by haemolymph must be regulated in accordance with these physiological requirements, so that the flight muscles are always sufficiently supplied with fuels. To achieve this, insects have a very complex regulatory system. 2. The flux of metabolites through the energy producing pathways in the muscles has to rise drastically. It is disputed that the following two mechanisms are able to regulate the fluxes through these pathways with the necessary velocity and sensitivity: a) the increase of the activity of non-equilibrium enzymes by changes of the concentrations of regulators; b) the increase of enzyme activities by interconversion cycles.

After a substrate cycle between glucose and glucose 6-phosphate has been demonstrated in the flight muscles of the death's-head hawk moth *Acherontia atropos* and after measuring the cycling rates of this cycle during rest and flight, substrate cycling seriously must be taken into consideration as a totally different mechanism for improving sensitivity of flux regulation.

## **R5.1.** CARBOHYDRATE AND LIPID CHANGES DURING PUPAL DEVELOPMENT OF

**2**

### CHIRONOMUS BARBATITARSIS

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Alterations of carbohydrate and lipid during the pupal developmental periods of Chironomus barbatitarsis showed notable declining levels in the early and late pupal periods. Both sugars and lipids showed sex wise variations. All the sugars showed higher levels in the male pupae while lipid was higher in the females. Integument showed marked alterations of lipid in respect of sugar while gut exhibited reverse trend of variations. Fat body and haemolymph presented notable alteration of all the contents in different developmental periods. Testis showed marked depletion of lipid while gradual accumulation of sugar in the early periods, in the late pupal periods both parameters showed considerable decline. Ovary showed fluctuating level of sugar while lipid appeared more or less uniform except notable fall of cholesterol during the whole periods.

**R5.1.**  
**3** CHEMISTRY AND BIOCHEMISTRY OF INSECT GLYCOLIPIDS

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A 'simplified' system (in vitro grown Kc cells: Drosophila melanogaster) and a 'complex' system (pupae: Calliphora vicina) have been used as sources for insect glycolipids. The chromatographic patterns of these components have been shown to be relatively simple and very complex, respectively. The chemical structures of the major constituents of the acidic and neutral fractions, both lipid and carbohydrate moieties, have been elucidated. By metabolic labelling, the biogenic relationships of the glycolipids and their behaviour during development, i.e. pupae and to ecdysterone, i.e. Kc cells have been investigated.

5

**R5.1.**  
**4** STUDIES ON ACID AND ALKALINE PHOSPHOMONOESTERASE IN  
THE COCONUT PEST, ORYCTES RHINOCEROS

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Biochemical and electrophoretic studies on acid and alkaline phosphomonoesterase in cuticle, midgut, hind gut and reproductive organs of larval and adult male and female of Oryctes rhinoceros were investigated. In larval tissues, the activity of the acid phosphomonoesterase was higher than that of the adult. In adult, the activity of the acid phosphomonoesterase was higher than that of the alkaline phosphomonoesterase in all the tested tissues. Phosphomonoesterase activity was higher in the female tissues than that of in the male tissues. Electrophoretic analyses of acid and alkaline phosphomonoesterases in various tissues of male and female O.rhinoceros indicate the existence of multiple forms of the enzymes. In the present study some electrophoretic fractions of acid and alkaline phosphomonoesterases are common and some are specific both in larval and adult tissues. The significance of these results have been discussed.

**R5.1.** GENETIC AND BIOCHEMICAL STUDIES ON HAEMOLYMPH PROTEASE  
**5** INHIBITORS OF THE SILKWORM

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Many electrophoretic variants of haemolymph protease inhibitors which inhibit pancreatic  $\alpha$ -chymotrypsin and fungal protease were found using 126 silkworm strains. Crossing experiments showed that the expression of each inhibitor band is controlled by a pair of alleles corresponding to the strong and null bands respectively. In the column experiments, inhibitors against different proteases showed distinct elution patterns, but some fractions were similar in elution positions. Partially purified chymotrypsin inhibitors were classified into two groups, low (a,e,g) and high molecular weight (c,d). The former was heat stable whereas the latter was labile. Ouchterlony's double diffusion method indicated that fraction c and d are immunologically identical. However, there was no immune precipitate between low molecular weight inhibitor(s) and anti-d serum.

**R5.1.** UDP-N-ACETYLGLUCOSAMINYL TRANSFERASES OF THE STABLE FLY STOMOXYS  
**6** CALCITRANS

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UDP-N-acetylglucosaminyl transferases were studied in 0-day pupae of the stable fly, Stomoxys calcitrans using dolicholmonophosphate as the lipid acceptor. The mono- and disaccharide substituted dolichol phosphate was assayed using a DEAE-cellulose isolation technique. Substantial enzyme activity was located in the 10,000 and 100,000 xg pellets of pupal homogenates. Maximum enzyme activity occurred at pH 7.5 in the presence of 5 mM  $Mg^{++}$  and monovalent ions such as  $K^+$  had little effect on activity whereas  $Mn^{++}$  stimulated activity ca. 30%. EDTA, uridine, UTP, UDP, and UMP inhibited the reaction to various extents. Experiments showed that tunicamycin was an effective inhibitor of the transfer of GlcNAc units to dolichol phosphate. Only the transfer of the first GlcNAc unit was inhibited by tunicamycin; transfer of the second GlcNAc unit was unaffected. Diflubenzuron had no effect on the reaction.

R5.1.  
7

N- $\beta$ -ALANYLDOPAMINE: SYNTHESIS AND METABOLISM FOR PUPAL CUTICLE TANNING  
IN MANDUCA SEXTA (L.)

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N- $\beta$ -Alanyldopamine (NBAD) is the main precursor for tanning of pupal cuticle in the tobacco hornworm, Manduca sexta (L.). Its synthesis is initiated by 20-hydroxyecdysone shortly after pupal apolysis and it accumulates to maximal titres (4mM) in haemolymph a few hours before ecdysis. NBAD occurs mainly as a  $\beta$ -glucoside before ecdysis, but free NBAD increases to peak titres (1.8 mM) by 6 hrs post-ecdysis as the conjugate disappears. There is a continuous uptake and accumulation of free NBAD in pupal cuticle and a subsequent decline in haemolymph levels as tanning proceeds. A probable metabolite of NBAD, N- $\beta$ -alanylnorepinephrine, also accumulates in tanning pupal cuticle.

5

R5.1.  
8

TRANSLATIONAL CONTROL AT THE ONSET OF POST-DIAPAUSE DEVELOPMENT  
IN BOMBYX EMBRYOS

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Many studies on embryonic gene activity have aimed at revealing the control of protein synthesis, the rate of which increases after fertilization. The Bombyx embryo may provide a significant system for such study because of its onset and termination of diapause. We did in vitro translation (heterologous) of total RNA extracted during the early period of post-diapause development, where the general rate of protein synthesis rises. The following results implied the control at the level of translation: a) The translational activity of bulk RNA did not increase; b) the basic spectrum of translates remained unchanged; c) the effect of the methylation inhibitor SAH indicated that the amount of methylated mRNA increased. We also found temporarily existing specific mRNA which coded for 73k protein(s) during a certain period prior to the onset of morphogenesis.

**R5.2.** EFFECT OF 25-AZASTEROIDS ON DEVELOPMENT AND SITOSTEROL  
1 METABOLISM IN SPODOPTERA LITURA (F.).

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The sterol requirements of the tobacco caterpillar, Spodoptera litura (F.) can be met by sitosterol. This sterol can be dealkylated to cholesterol in S. litura. As insects have a dietary requirement for sterols, any disruption of sterol utilization is likely to kill the insect and thus has the potential of being developed as a method of insect control. Azasteroids, namely 25-azacholesterol or 25-azacholestane when added to the larval diet along with sitosterol at a concentration of 1 ppm to 100 ppm reduced the larval and pupal weight and lengthened the time taken for development of S. litura. They also caused melanization of larvae and production of larval-pupal intermediates. Egg production and hatchability decreased with increasing azasteroid concentrations. These larvae also showed the presence of desmosterol, which is not detected in the normal insect. Higher concentrations of azasteroids in the diet resulted in an increase in desmosterol and sitosterol concentration and a simultaneous reduction in cholesterol formation. These results indicate that desmosterol is an intermediate in sitosterol dealkylation and its accumulation is due to the inhibition of the enzyme 24-sterol reductase.

**R5.2.** CHOLESTEROL METABOLISM DURING LARVAL PERIODS OF CHIRONOMUS  
2 BARBATITARSIS IN NORMAL AND APOSYMBIOTIC CONDITIONS

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The levels of total, free and esterified cholesterol were analysed in relation to age of the second, third and fourth larval instars of Chironomus barbatitarsis. Of the total cholesterol, 66.01 - 88.01% and 16.06 - 33.98% were accounted for free and esterified cholesterol respectively. Both forms exhibited a gradual increase in relation to age of the larvae (considering the contents during respective mid instar periods). The level of cholesterol forms appeared high around mid instar periods followed by considerable decline in subsequent periods. Both the contents showed significant increase at the pharate pupal period. In second and third instars, esterified cholesterol demonstrated gradual increase up to late instar periods while in the fourth instar the content presented fluctuating levels. All the contents were noted to decline during each moult. Aposymbiotic larvae showed significant declining levels of all the cholesterol forms.

**R5.2.** INVASIVE CHANGES IN FRACTION OF BASIC SOLUBLE PROTEINS OF  
**3** APIS MELLIFICA BROOD INFESTED BY VARROA JACOBSONI MITE

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Samples of blood withdrawn from drones of *Apis mellifica* slightly parasitized /V<sub>1-3</sub>/ and heavily infested /V<sub>4-6</sub>/ by *Varroa jacobsoni* were fractionated on acrylamide gel in discontinuous acidic buffer systems. Experiments reveal a great alterations in the number and density of cathodal protein fractions of a low molecular weight in parasitized bees, comparing to the electrophoretic pattern of the soluble proteins present in blood of the control uninfected larvae. A remarkable reduction of the content of total proteins in haemolymph of drone brood is related to the intensity of the invasion. The alterations in the patterns of haemolymph proteins are the result of protein depletion. Also possible are biochemical changes in the content of the soluble proteins following release of toxic substances into the body of the host during invasion.

A decrease in the total soluble proteins was confirmed following separation of haemolymphs under denaturing buffer system according to the method of Laemmli.

**R5.2.** ACTIVITY OF THREE PURIFIED ENZYMES OF THE ENDOPARASITIC STAGE OF  
**4** HYPODERMA LINEATUM (Diptera Oestridae) ON HUMAN AND BOVINE COMPLEMENT AND COAGULATION SYSTEMS.

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Three serine proteinases secreted by the first instar larvae of *Hypoderma lineatum* have been assayed for their ability to deplete seric complement of naïve or immune cattle. Their activity on component C3 have been compared in bovine and human sera. Modifications in the bovine and human coagulation and fibrinolysis have been observed at their contact. The complementary biological role of these enzymes in the host defense mechanisms is discussed.

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Ecdysteroid 22-phosphates constitute the major maternal ecdysteroids in newly-laid eggs of the desert locust, Schistocerca gregaria. These phosphates can undergo hydrolysis by a phosphatase enzyme during embryogenesis. A number of polar ecdysteroid derivatives which presumably represent hormone inactivation products have been identified in developed eggs of S. gregaria and include 3-acetylcaldysone 2-phosphate, caldyson-26-oic acid, 20-hydroxycaldysone-26-oic acid, together with smaller amounts of 3-acetyl-20-hydroxycaldysone-2-phosphate, 3-(and/or 2-)acetylcaldysone 22-phosphate, and 3-epi-2-deoxycaldysone 3-phosphate. Formation of many of these metabolites has also been detected in larvae. In some insect species, formation of 3-epiecdysteroids via the corresponding 3-dehydro compounds is a significant route of hormone inactivation.

Metabolism of ecdysteroids to 'apolar' fatty acyl ester derivatives has been detected in ticks. In adult female Boophilus microplus, such esters, which may represent inactive storage forms of the hormone, are transferred into the eggs. An enzyme system from developing tick eggs catalyses hydrolysis of the acyl esters releasing caldysone. The occurrence of analogous 'apolar' ecdysteroid esters in insects will be considered.

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It is now well documented in several insect species that large amounts of conjugated 2-deoxycaldysone and caldysone are synthesized in the follicle cells of vitellogenic ovaries, transferred into the oöcyte and converted in the eggs during embryogenesis to a variety of free and conjugated ecdysteroids. Two questions will be primarily addressed in the lecture : (1) Is 2-deoxycaldysone to be regarded as a hormone *per se* during embryogenesis or does it serve as a precursor molecule for caldysone and 20-hydroxycaldysone? (2) At which stage is the embryo capable of *de novo* synthesis of caldysone and, therefore, potentially independent of the maternal ecdysteroid supply? In an attempt to answer these questions, high specific activity tritiated (22,23,24,25)-<sup>3</sup>H<sub>4</sub>-3,14-dihydroxy-5 $\beta$ -cholest-7-en-6-one<sup>\*</sup> and (23,24)-<sup>3</sup>H<sub>4</sub>-2-deoxycaldysone have been synthesized<sup>\*\*</sup>. The conversion of these molecules has now been investigated in various compartments of the eggs at essential stages of embryogenesis; the results will be presented and discussed in relation to these two questions.

<sup>\*</sup>Hetru C., Nakatani Y., Luu B., Pichat L., Rousseau D. and Meister M., submitted.

<sup>\*\*</sup> Hetru C., Nakatani Y., Luu B. and J.A. Hoffmann, Nouveau Journal de Chimie, 7, 10, p. 587, 1983.

## §5.1. 3 CONTROL OF GENES BY ECDYSTEROIDS

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Studies on the mode of action of ecdysteroids have received a new impetus due to the introduction of P element transformation in *Drosophila melanogaster* (Rubin and Spradling 1982, Science 218, 348). In this system the functional properties of an *in vitro* modified segment of DNA can be tested by its reintroduction into the fly chromosomes and its subsequent heritable transmission. By constructing deletions and rearrangements of the sequences flanking the transcribed coding region, studies are underway to delimit the DNA regulatory sequences necessary for the stage and tissue specific expression of a gene at its normal level of activity. In the case of genes known to be regulated by ecdysteroids these regions should include the sequences recognised by the steroid hormone and its receptor or binding proteins. We have chosen to study the salivary gland glue secretion protein 3 and have previously shown that all the necessary information is contained in a 7 kb genomic segment (Richards et al., 1983, EMBO J. 2, 2137). We now discuss the results of deletion analysis in this segment and present evidence from this study for the complexity of regulatory elements in eukaryotic genes.

5

## §5.1. 4 AZADIRACHTIN IS AN ANTI-ECDYSTEROID

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The natural insecticide azadirachtin isolated from the Neem tree interferes during insect development with a variety of processes controlled by ecdysteroids. We favour the working hypothesis that the effects of azadirachtin are due to its interaction with ecdysteroid receptors, thus leading to a disturbance of the hormone system.

Our hypothesis has been tested using larvae and pupae of the blowfly *Calliphora vicina*. Azadirachtin competes with ecdysteroids for hormone binding sites. Its affinity in a receptor binding assay is equal to that of ponasterone A. However, important characteristics of the hormone receptor complex seem to be altered.

Further tests using radioactive azadirachtin are under way to prove the potency of the substance as a useful tool in receptor studies.



## §5.1. 5

### ECDYSTEROID METABOLISM IN TICKS

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We investigated the metabolism of injected or ingested ecdysteroids in immature and mature stages of the ticks *Amblyomma hebraeum* (Ixodidae) and *Ornithodoros moubata* (Argasidae). Ecdysone (E) is efficiently converted to 20-OH-E and then to more polar compounds. In a second pathway, E and 20-OH-E are esterified with fatty acids. These esters represent a new class of apolar conjugates which have not yet been found in other arthropods. The possible significance of both pathways will be discussed.

## §5.1. 6

### ECDYSTEROID TITERS IN ARTIFICIAL HIBERNATING PUPAE OF ERISILKWORM, PHILOSAMIA CYNTHIA RICINI

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Eri-silkworm is a kind of non-hibernation multivoltine insects. By letting the larvae pass through "Late Autumn-Like" conditions through 3 successive generations, we have succeeded in selecting a new strain of P. cynthia ricini which can hibernate in the forms of pupae. Here we report haemolymph ecdysteroid (MH) titers, determined by RIA, in both hibernation-bound and non-hibernation-bound pupae of Eri-silkworm. For those non-hibernation-bound pupae, emerged on an average of 37 days, the MH titer was around 50 pg/μl haemolymph shortly after pupation. Then it increased gradually and reached a high peak of 400-800 pg/μl around day 17. Afterwards it gradually decreased. For those hibernation-bound pupae, emerged on an average of 97 days, the MH level after pupation was around 40 pg/μl. Then it gradually decreased to below 10 pg/μl. After 87 days there was a sudden rise to 100 pg/μl, and a sudden drop after the peak. In addition, no MH peak could be observed in the haemolymph when the brains were extirpated in hibernation-bound pupae 30 days after pupation. It showed the critical period of brain hormone secretion was delayed. The above results reveal that the cultivated strain has obtained the characteristics of the artificial hibernation during the pupal stage under "Late Autumn-Like environment" conditions.

SS.1.  
7

## THE FATE OF ECDYSTEROIDS IN CALLIPHORA LARVAE

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Some parameters which are involved in regulation of the ecdysone titre were examined in Calliphora vicina third instar larvae:

- the ecdysteroid haemolymph titre
- the haemolymph volume and the distribution volumes of water and ecdysteroids
- the pool size of circulating ecdysteroids
- the metabolic half-lives of ecdysone and 20-hydroxyecdysone
- the quantitative contribution of various tissues to the ecdysone metabolism
- the excretion and metabolic clearance of ecdysteroids
- the type of ecdysteroids excreted

## SS.1. 8 ECDYSTEROIDS IN ADULT MALES OF GRYLLUS BIMACULATUS AND BLAPTICA DUBIA

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The occurrence of ecdysteroids in adult males of insects is only known from a few species. In the males of Gryllus bimaculatus the hormone titre was investigated within the first 16 days of adult life. Immediately after ecdysis the titer shows the same values as were found in the late nymph. Then it reaches maxima at days 4, 8, 12, 14 and 15 with an average of 1600 ng/g wet weight. Between these maxima titre falls back to a base level of 20-50 ng. The hormone peaks in males occur with a delay of about 1 day in comparison with the maxima observed in females. Isolated ♂♂ are showing these peaks too. Beside ecdysone and 20-OH-E there exists probably another compound, as was shown by HPLC and GLC. The ecdysteroids were synthesized within the adult period as was demonstrated by conversion of <sup>3</sup>H-labelled cholesterol. A great part of these hormones was found in faeces, which is a hint that they are excreted rapidly. The hormones were not only confined to few organs but were found in testes as well as in accessory glands, fat body, tergites, oenocytes and carcass. - In the longliving roach Blaptica dubia a relatively elevated ecdysteroid titre is to be observed for six days after adult ecdysis. The following reduction of the titer corresponds with the formation of egg cases in females.

## §5.1. A QUALITATIVE AND QUANTITATIVE STUDY OF THE NON ECDYSTE- 9 ROID STEROIDS IN HAEMOLYMPH OF *LEPTINOTARSA DECEMLINEATA*

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After our earlier identification of 14 non-ecdysteroid steroids in haemolymph of larvae of the Colorado potato beetle, we investigated whether sex-specific or development dependent changes in steroid pattern and/or concentration occur.

Haemolymph from reproducing adult males and females was collected and extracted. After preparing the O-pentafluorobenzyloxime (OPFB)-heptafluorobutyryl (HFB) derivatives of these haemolymph extracts, negative chemical ionization gaschromatography-mass spectrometry (NCI/GC-MS) was used to identify the steroids.

We also determined the testosterone and progesterone titer during the life cycle of this insect by means of radioimmunoassay. Prior to RIA, haemolymph samples from larval, pupal and adult stages were extracted and subjected to column chromatography on Sephadex LH 20.

## §5.1. REGULATION OF JUVENILE HORMONE BIOSYNTHESIS 12

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The identification of the regulatory mechanisms controlling juvenile hormone biosynthesis is a major goal of insect endocrinology. Studies of juvenile hormone biosynthesis in vivo have suggested both neural and humoral influences. We have studied the incorporation of a variety of radiolabeled precursors into juvenile hormone by the isolated corpora allata of several species of paurometabolous insects. These investigations have yielded evidence indicating humoral and metabolic mechanisms of regulation.

## 55.1. STEREOCHEMISTRY OF JUVENILE HORMONE BIOSYNTHESIS, TRANSPORT, 13 AND DEGRADATION

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The juvenile hormones of insects are optically active natural products. Chirality results from the presence of an unsymmetrically substituted epoxide. We found that, in addition to stereospecific enzymatic epoxide formation, there are enantioselective enzymes catalyzing methyl group transfer to JH-acid or carboxyl ester hydrolysis. JH-carrier proteins bind selectively one or all of the homologous hormones. Differences exist within species from several insect orders. The substrate specificity - including stereospecificity - of proteins involved in JH metabolism is important for the mechanism of hormone titer regulation and for the mode of action of JH analogs as potential insecticides.

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## 55.1. JUVENILE HORMONE CONTROL OF VITELLOGENESIS 14

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In many insects, production of yolk precursor protein, vitellogenin (Vg), in fat body is controlled by JH, and this can provide a convenient system for analysis of JH action at the cellular and molecular levels. In Locusta migratoria, adult female fat body responds strongly and directly to JH or an analogue such as methoprene by transcription of Vg mRNA and translation to primary polypeptides, followed by glycosylation, cleavage, dimerization and secretion of Vg into the hemolymph. Synthesis of a second, much smaller protein is also induced. These specific responses are given only weakly by larval fat body and not perceptibly by adult male tissue. Recent work has concentrated on cloning and structural analysis of JH-regulated genes. Two locust Vg genes from the X chromosome have been cloned along with flanking sequences from genomic DNA. Although they code for mRNAs of the same size, the two Vg genes show no apparent molecular hybridization. Coding regions extend over 10-12 kb, are interrupted by introns, and are accompanied by multiple short repeat DNA units of unknown function. Selected DNA sequences are being determined and cloned probes are being used for the study of gene expression in response to the JH analogue.

## §5.1. 15 EXPRESSION OF THE VITELLOGENIN GENE IN THE MOSQUITO *Aedes aegypti*.

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Both ecdysterone and juvenile hormone are known to influence vitellogenin synthesis in *Aedes aegypti*, but their precise roles have not been established. We cloned the vitellogenin gene and measured its expression before and after a blood meal. We also examined the effect of juvenile hormone and ecdysterone on expression of the gene *in vivo* and *in vitro*. The results of these studies were compared to titer curves of juvenile hormone and ecdysterone. We conclude that ecdysterone stimulates the expression of the vitellogenin gene, but that other factors that appear after the blood meal are also necessary. These factors may be nutritional.

## §5.1. 16 THE ROLE OF JH AND ECDYSTEROIDS IN REGULATING HEMOGLOBIN AND VITELLOGENIN SYNTHESIS DURING CHIRONOMUS DEVELOPMENT

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Hemoglobins (Hbs), and vitellogenins (Vgs) are hormonally regulated during *Chironomus* development. While Hbs exist as a multigene family and are characteristic of larval stages, the Vgs are restricted to the pupal-adult transformation. Ecdysteroids and juvenile hormone (JH) play a significant role in the fluctuations of 9 Hbs seen as soluble hemolymph proteins. The JH analogue, methoprene, activates synthesis of Hbs 2 and 3 by initiating transcription in the fat body at a concentration of  $10^{-7}$  g/l. At larval and pupal molts ecdysteroid concentrations increased, while Hb synthesis decreased. Ecdysteroids administered to short term organ cultures reduce Hb synthesis by regulating post transcriptional events. The same concentration of methoprene that stimulates Hb synthesis induces the precocious onset of Vg synthesis in the larval fat body. While the JH titers of *Chironomus* pharate adults are still to be determined, Vgs are synthesized in normal females in an increasing ecdysteroid concentration. Ecdysteroids reach 450 ng/ml in the hemolymph of vitellogenic females, decreasing to 50 ng/ml at the point of oviposition on day two of adult life. This is also the ecdysteroid level of adult males. Thus it is concluded that in *Chironomus*, both JH and ecdysteroids are needed for normal vitellogenin synthesis, as well as for Hb synthesis and degradation. The interesting point is that the target of regulation is the fat body which persists in the larva and through metamorphosis to the adult.

## 55.1. VITELLOGENIN SYNTHESIS IN CALLIPHORIDAE : SITES OF SYNTHESIS 17 AND CONTROL BY ECDYSTEROIDS

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In anautogenous as well as incipient autogenous Calliphoridae species there is a food mediated arrest of vitellogenin synthesis and concomitant ovarian development. In these flies ecdysteroids, demonstrated to be absent in hemolymph of males but present in female hemolymph, have been proven to play a major role in the induction of vitellogenin synthesis. Using male flies as an adequate *in vivo* system in combination with a reticulocyte cell free translation system, we came to the conclusion that the interaction of ecdysteroids on gene expression has to be situated, at least partially, at the transcriptional level. In flies both fat body cells and follicle cells have been recognized as sites of synthesis of vitellogenin but so far only an effect of ecdysteroids on fat body cells has been reported. Even in the fat body itself different cells might react to ecdysteroids in a different way. Indeed, in a recent immunocytochemical study on the distribution of vitellogenin and lipoprotein in fat body of vitellogenic females, we found that some cells synthesize only vitellogenin, others only lipoprotein and still others both.

## 55.1. ON THE VITELLOGENESIS OF COCCINELLA SEPTEMPUNCTATA: 18 VITELLOGENIN SYNTHESIS AND HORMONAL REGULATION

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Vitellogenin (Vg) synthesis and secretion by the fat body of female lady beetle were studied by measuring the [<sup>3</sup>H]leucine incorporation in vitro into Vg after specific antibody precipitation. In vitellogenic females, the radioactive Vg secreted into the medium showed a quick linear increase for 4 hr, whereas that retained in the tissue accumulated slowly and remained at a low level. The percentage of Vg secreted by the fat body was less than 40% at 30 min and increased to a maximum of about 90% by 4 hr.

In females feeding on aphids, Vg synthesis began at day 3 after emergence and became maximal at day 13. The incorporation of [<sup>3</sup>H]uridine into fat body RNA reached a maximum at day 9, which preceded the major rise in Vg synthesis. Very little Vg synthesis occurred in females reared on a basic artificial diet. The Vg produced was less than 3% of that made in aphid-feeding females at the peak of Vg synthesis. Synthesis of RNA and other secretory proteins were reduced to a lesser extent.

Treatment with a JH analog ZR512 stimulated Vg and RNA syntheses in fat body from females on artificial diet. The result confirmed the involvement of JH in the regulation of Vg synthesis and secretion in this species, and is consistent with action of JH at the transcriptional level.

**55.1.** SPECIFIC BINDING OF VITELLOGENIN TO OOCYTE MEMBRANES OF THE OVOVIVIPAROUS COCKROACH, NAUPHOETA CINEREA  
**19**

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In order to investigate the presence of vitellogenin binding sites on the oocyte membranes and to study the mechanism of vitellogenin incorporation and its control by juvenile hormone we have developed an in vitro binding assay. In this assay oocytes are drained of yolk and the cortices, consisting of the oocyte plasma membrane, the follicular epithelium and the basement lamella, are incubated in an artificial medium containing  $^{14}\text{C}$ -labelled vitellogenin. Incubation is stopped by centrifugation; the membrane pellet is washed with incubation buffer and hydrolyzed using NaOH, and the bound vitellogenin is then measured by liquid scintillation counting. Using this method we observed that  $^{14}\text{C}$ -vitellogenin was bound to oocyte membranes of vitellogenic females in a saturable manner. Binding was shown to be specific, since unlabelled vitellogenin and vitellin competed with labelled vitellogenin for binding, whereas other proteins of female cockroach haemolymph did not do so. Binding reached an equilibrium within 1 hour of incubation at  $4^{\circ}\text{C}$  or  $26^{\circ}\text{C}$ . The quantity of specific binding was proportional to the amount of membrane protein present in the assay. Scatchard analysis revealed a  $K_D$  of approximately  $6 \times 10^{-7}\text{M}$  and a concentration of binding sites of approximately  $10^{-7}\text{Mol/g}$  membrane protein. Scatchard plots of specific vitellogenin binding showed upward convexity, suggesting a positive cooperativity effect.

**55.1.** ACTIVATION OF THE CORPORA ALLATA DURING PREGNANCY IN THE VIVIPAROUS COCKROACH, DIPLOPTERA PUNCTATA  
**20**

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Corpora allata (CA) of the viviparous cockroach, Diploptera punctata, synthesize juvenile hormone (JH) at low rates during the 60-day gestation period. The mechanism that restrains the rate of JH synthesis during early pregnancy was investigated by operating on females at 10 days of pregnancy and 9-13 days later assessing JH synthesis radiochemically and by the growth of basal oocytes. If CA were denervated, 54% of the operated animals responded with increased CA activity and oocyte growth; implantation of a previtellogenic ovary did not increase that percentage. If embryos were removed from the brood sac, 31% responded similarly. If both operations were performed on the same animal, 87% responded. Removal of the brain (by decapitation and implantation of CA) resulted in 80% responding. We conclude that inhibition of the CA during early pregnancy occurs via 2 pathways in the brain and one reaches the CA via intact nerves whereas the other travels in the haemolymph.

**55.1.** REGULATION OF THE CORPORA ALLATA ACTIVITY BY HUMORAL FACTORS IN THE  
**21** OVOVIVIPAROUS COCKROACH NAUPHOETA CINEREA

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We have shown for the first oocyte maturation cycle that the rate of juvenile hormone synthesis by the corpora allata (ca) is precisely related to oocyte growth, increasing until chorion formation and then falling sharply towards ovulation. This relationship between ca activity and oocyte growth has also been observed in decapitated females with implanted ca, indicating that humoral factors are responsible for ca regulation. In addition, ovary removal and transplant experiments have shown that the major ca regulating influence comes from the ovary.

Here we report on long-term ca cultures in media composed of tissue culture medium and haemolymph or fractions thereof, the haemolymph having been collected from males or females at selected stages. The results indicate the presence of both ca activating and inactivating factors in haemolymph depending on the developmental stage, and the possibility of isolating and identifying such factors by using this in vitro system thus appears promising.

**55.1.** PHOTOPERIODIC REGULATION OF JUVENILE HORMONE AND REPRODUC-  
**22** TION IN THE CARABID BEETLE, PTEROSTICHUS NIGRITA

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The reproductive dormancy of *Pterostichus nigrita* can be overcome by a sequence of short-day (SD) and long-day (LD). This hibernation dormancy is an adaption to climates with cold winters. Females emerging in late summer remain immature (LD), but reach the stage of previtellogenesis in autumn (SD) critical photoperiod 15/9). In the following spring they reach the stage of vitellogenesis and oviposit (LD, critical photoperiodic LD 13/11). The measurement of daylength is based on circadian processes. In males and females maturation is regulated by the hormone of the corpora allata (CA), the juvenile hormone. Photoperiodical treatment can be replaced by application of juvenile hormone. Using a radiochemical assay it was found that LD-CA are low active, SD-CA are moderate active and that CA from SD/LD treated beetles are very active. The stepwise activity of the CA is caused by photoperiodically controlled synthesis and release of neuroendocrine factors.



**§ 5.1.** STUDIES ON PHEROMONAL CONTROL OF NEOTENIC REPRODUCTIVE DEVELOPMENT  
**23** IN TERMITES USING AN IN VITRO RADIOCHEMICAL ASSAY.

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Development of neotenic reproductives in the termite Zootermopsis angusticollis is inhibited by pheromone(s) produced by the queen and king. Inhibition of development caused by the pheromone can be linked to a change in the rate of juvenile hormone synthesis as shown in this study. A radiochemical assay which measures rates of juvenile hormone synthesis by corpora allata incubated in vitro was adapted for use with the termite as an assay for the pheromone. Rates of juvenile hormone synthesis by corpora allata incubated in vitro were significantly higher for larvae without a queen and king (QK-) as compared to larvae with a queen and king (QK+).

Exposure of larvae to extracts from male and female reproductives mimicked the inhibitory effect of the queen and king. QK- larvae, exposed for 9 days to filter paper treated with methanolic head extracts, showed identical rates of juvenile hormone synthesis in vitro as larvae with a queen and king. Both groups of larvae had significantly lower juvenile hormone synthesis rates than QK- control larvae. The radiochemical assay may provide an excellent tool to monitor the purification of the active factor from head extracts.

**§ 5.1.** WHAT MEANS ZERO JUVENILE HORMONE CONCENTRATION IN ABSOLUTE  
**24** PHYSIOLOGICAL TERMS?

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The dissociation constant for the receptor JH-complex is unknown.  $K_D$  values in the range of  $10^{-8}$  -  $10^{-10}M$  are under discussion during defined steps of insect development. In analytical terms does that mean, that methods for qualitative and quantitative JH-estimations must be available with a sensitivity of 0.03 - 3 ng per gram of biological material. Using standardized methods of microderivatization and capillary GC-MS-MIS in the CI mode, titre curves were measured from several insect species during their larval development. Most of the insect species use JH-III exclusively and only some of them have trace amounts of additional JH-I. The hormone peaks are usually of short duration. The consequences from these data, also in relation to ecdysteroid titres, for an understanding of hormone action will be discussed.

55.1.  
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THE DIFFERENTIAL EFFECTS OF METHOPRENE DURING THE DEVELOPEMENT OF  
E. CAUTELLA WITH REFERENCE TO ECDYSTEROIDS LEVEL AND RNA SYNTHESIS

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The Jh analog methoprene (ZR515), was found to interfere with the normal embryogenesis of Ephestia cautella (Phyticidae, Lepidoptera) in a manner dependent on dose and age. Young embryos prior to the stage of blastokinesis were found to be the most sensitive to the compound. Methoprene inhibited metamorphosis (supernumerary giant larvae) when it was given to larvae 5 days prior to pupation or younger. However, when given 1-3 days before pupation, it did not affect metamorphosis but, it did cause full pupal mortality. Young pupae within one day of pupation also were found to be very sensitive to the compound. It appeared that a small ecdysteroid peak detected shortly before the wandering stage, about 4 days prior to pupation, was responsible for larval pupal transformation. The production of supernumerary larvae as a result of methoprene application was found to be associated with the absence of this ecdysteroid peak.

Methoprene was also found to prevent the formation of heterodisperse nuclear RNA which is induced by the above mentioned ecdysteroid peak. This RNA species was found to occur in the epidermal cells when the larvae become irrevocably committed to pupation.

55.1.  
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THE INFLUENCE OF JH ON THE CASTE SPECIFIC GLYCOGEN METABOLISM  
IN BUMBLBEES

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Queens of Bombus terrestris store large amounts of glycogen in the fat-body during the first adult days prior to hibernation. In workers, the glycogen content remains low. Caste specific differences in the metabolism are controlled by JH. A low hormone titre characteristic of queens increases the activity of glycogen-synthetase. After injection of JH in newly emerged queens the activity of glycogen-synthetase remains low comparable to the activity found in workers. The activity of phosphorylase, in contrast, seems not to be influenced by JH.

**55.1.** THE ROLE OF JH III IN THE TEMPERATURE DEPENDENT REPRODUC-  
**27** TION RATE OF CRICKETS, *GRYLLUS BIMACULATUS* (ORTHOPT.)

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Recently we have demonstrated a temperature dependence in the presence of ecdysteroids in adult female Mediterranean field crickets, *Gryllus bimaculatus*. As a result of the change of rearing temperature from a constant high (27°C) or a daily alternating temperature (24:12°C, 16:8 h) to constant 20°C the following phenomena were induced: a delay in the appearance of maximal levels of ecdysteroids in haemolymph and tissues, a decrease in absolute amounts of moulting hormones, and a slowing down of oocyte growth and egg deposition rate.

The present data reveal juvenile hormone III as a further candidate for a direct involvement of hormones in the temperature response of ovarian growth and oviposition. The rate of in-vitro JH III synthesis by the corpora allata is highest at 27°C and lowest at 20°C. Medium values are obtained at 24:12°C. In addition the first peak in JH III synthesis is reached 2 to 6 days earlier when animals have been reared at 24:12°C and 27°C than under 20°C. Vitellogenin appears in the haemolymph soon after the first peak in JH synthesis, but before the maximum in ecdysteroid level. Repeated applications of JH III (5 µg/animal) onto 20°C females significantly stimulated oviposition.

Supported by the Deutsche Forschungsgemeinschaft-SFB 87/ A 4.

**55.1.** EFFECT OF JUVENILE HORMONE ANALOGUE ON PUPAE OF THE HORSE  
**28** FLIES TABANUS STRIATUS (DIPTERA: TABANIDAE).

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The Juvenile hormone analogue, (E)-4- [(6,7-epoxy-3-ethyl-7-methyl-2-nonenyl) oxy], benzene were applied topically to pupae of Tabanus striatus Fabr. The effect of Juvenile hormone analogue occurs immediately after application. It interfered with glycogen content of treated pupae. After the application of higher doses the emergence of adult was not observed and it seemed that the pupae were dead.

**55.1.** EFFECT OF JUVENILE HORMONE AND JUVENOIDS ON THE GROWTH  
**29** OF WING DISCS IN GALLERIA MELLONELLA

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The volumetric growth of wing discs and the rate of cell divisions considerably increase after 24 hr of the last larval instar. The increase depends on the absence of juvenile hormone (JH). In larvae with the implants of corpora allata the growth acceleration is suppressed and the discs continue growing at the low larval rate. The larval growth pattern is also maintained in larvae that receive a juvenoid within 36 hr of the instar. Treatments at 48-72 hr have no effect on the rapid volumetric increase of the discs in the next two days but afterwards, within a day before the supernumerary larval-like ecdysis the size of the discs rapidly decreases and approaches that typical for larval development. The mitotic rate is reduced until no divisions are seen at ecdysis. The results indicate that JH and juvenoids induce continuation of the larval growth pattern if applied before some cells become committed for differentiation into the wing tissue. Proliferation of the committed cells cannot be blocked with the hormone but many of the cells probably later die and this leads to the reduction of the disc size.

**55.1.** ALLATECTOMY IN YOUNG ADULT MALE GRYLLOTALPA GRYLLOTALPA  
**30** LENGTHENS THE LIFE SPAN BY INHIBITING THE SENESCENCE  
PROCESSES.

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Allatectomy in young adult male Gryllotalpa gryllotalpa just after the emergence (2 hr after emergence) results in the long life span in comparison to the sham-operated controls. Of the allatectomized insects 80% of the population lived upto 140 days while the 20% of the sham-operated insects lived upto 120 days under controlled laboratory condition ( $25^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$ ; 80% RH and 12 L : 12 D photoperiod). The fat body and haemolymph of the allatectomized insects showed acid phosphatase, general esterase and peroxidase activity in steady condition with age while the activity of these enzymes in both fat body and haemolymph of sham-operated insects showed significant augmentation with age. The activity of catalase in both haemolymph and fat body of allatectomized insects showed significantly greater in amount in comparison to the sham-operated insects with age and the reverse results have been found in the  $\text{H}_2\text{O}_2$  concentration. The rapid increase in the activity of acid phosphatase, general esterase, peroxidase and accumulation of  $\text{H}_2\text{O}_2$  in both the fat body and haemolymph of sham-operated insects with age probably enhances the rapid senescence processes which ultimately leads to the shorter life span in sham-operated control insects in comparison to the allatectomized insects.

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More than thirty small peptides are known existing in neurons. There is much evidence that these neuropeptides are released from these neurons. More than twenty neuropeptides are considered as putative neurotransmitters. Little is known about the mode of action of the most neuropeptides. Increasing evidence derived mainly from immunohistochemical studies indicates that neuropeptides may occur together with a classical transmitter in one and the same neuron. The pentapeptide proctolin is present in terminal structures in the nervous system of insects ( and mammals ?). It has a strong contracting effect on different insect muscles. Its mode of action in comparison to other neuropeptides is considered and discussed.

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The eclosion hormone (EH) from the moth Manduca sexta is a peptide neurohormone that acts on the nervous system to trigger ecdysis and associated behaviors. EH was purified from methanolic extracts of pharate adult corpora cardiaca. Gel filtration chromatography on Sephadex G50 and Biogel P-10 columns estimated the molecular weight of EH to be about 8500 daltons. Further characterization using denaturing urea-SDS polyacrilamide gels yielded a value of approximately 4300 daltons. The latter value is most likely correct and EH probably exists as a dimer in physiological solutions. Electrofocusing gels showed the peptide has a pI of about 4.8. On reverse-phase C-18 columns using HPLC, EH shows a high degree of hydrophobicity.

The peptide is distributed between two sites in the CNS: one associated with the brain and the other with the chain of ventral ganglia. The respective release sites are used at different times in the insect's life history and also are regulated by different factors. The ventral ganglion site is used at the end of the larval and pupal molts and appears to respond directly to circulating levels of ecdysteroids. The brain center is used at the end of the adult molt and is responsive to both steroid levels and to circadian inputs.

## 55.1. 33

### ADIPOKINETIC AND PHOSPHORYLASE-ACTIVATING PEPTIDES IN LOCUSTS.

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There are at least two hyperlipaemic and phosphorylase-activating factors in the CC of locusts. The best studied of these is adipokinetic hormone (AKH 1), a decapeptide which mobilises diacylglycerols from stores of triacylglycerol in the fat body and stimulates fat oxidation in the flight muscles.

The second peptide, AKH 11, is distinct, both in its amino acid composition and in its biological activities from AKH 1 and from the prawn red pigment concentrating hormone (RPCH). As far as lipid mobilisation is concerned, at low doses AKH 11 appears to be almost as active as AKH 1, but at higher doses it fails to elicit as great a change in haemolymph lipid or lipo-protein as does AKH 1.

The relative activities of these two peptides in causing hyperlipaemia and in activating glycogen phosphorylase will be discussed.

## 55.1. 34

### DIURETIC HORMONES IN LOCUSTS

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Diuretic factors (DH's) which regulate the transport of ions and water by locust Malpighian tubules can be extracted from all parts of the CNS. HPLC has been used to separate these diuretics; in particular those from the corpus cardiacum, and two distinct entities are revealed. At least one of diuretics is susceptible to proteolytic digestion by trypsin and chymotrypsin confirming that one form of DH is a peptide. Successful characterization of this peptide has been hampered by the poor fluid secretion bioassay used to detect hormone activity.

A novel method of hormone assay, measuring the elevation in cAMP levels resulting from DH stimulated adenylate cyclase in both intact and broken Malpighian tubule preparations has been developed, and its use in the purification of DH described. As this bioassay method exploits the specificity between hormonal ligand and receptor, it is an assay which could be applied to the isolation and characterization of many biologically active peptides and amines.

In addition to a receptor acting via cAMP, chromatographic evidence indicates that another diuretic compound acts independently of cAMP, and therefore via a second receptor. Interestingly, 5-HT stimulates fluid secretion in a dose-dependent manner, but not via cAMP. Dual receptor stimulation of the Malpighian tubules is discussed.

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The chemical and biological properties of neurohormones extracted from Bombyx mori have been investigated.

Prothracicotropic hormone (PTTH): The presence of two kinds of PTTH has been established in the brain of Bombyx mori: one (4k-PTTH; Mwt. ca. 4.5k daltons) specifically provokes the adult development of Samia brainless pupa and other (22k-PTTH; Mwt. ca. 22k daltons) specific to Bombyx brainless pupa. The chromatography indicated the presence of three molecular forms of 4k-PTTH, two of which were isolated.

Eclosion hormone (EH): EH was extracted from both the adult and pharate adult heads of Bombyx mori and proved to be a peptide (Mwt. ca. 8.4k daltons).

Melanization and reddish colouration hormone (MRCH): A peptidal hormone, MRCH (Mwt. ca. 7k daltons), inducing cuticular melanization in the isolated larval abdomen of Leucania separata, was extracted from the adult heads of Bombyx mori, although the role of MRCH in Bombyx is unknown.

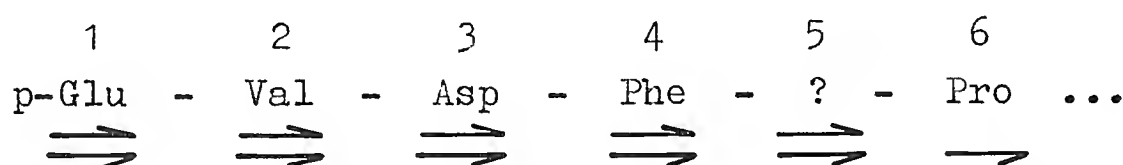
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Neurohormone D is one of the heart active peptides of the corpora cardiaca of Periplaneta americana. It is purified by a four step isolation procedure. It has a dose-dependent stimulating effect on the cockroach heart beat by injection in intact animals, with a half live time of 5 - 10 min.

Membrane fractions of Malpighian tubules destroy the hormone activity, suggesting a membrane bounded peptidase.

The molecule has a blocked amino terminal amino acid. The results of dansyl-Edman degradation (—) as well as the degradation with Dabite (—) after methanolysis indicate now the partial structure:



## §5.1. ADIPOKINETIC AND HYPERGLYCAEMIC FACTORS FROM THE 37 CORPORA CARDIACA OF VARIOUS INSECT SPECIES

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Separations of corpus cardiacum (CC) extracts from various species were achieved with HPLC methodology. Locusta migratoria CC extract showed two absorbance peaks with adipokinetic activity. AKH I contained the following amino acid residues: Asp<sub>(2)</sub>, Thr<sub>(2)</sub>, Glu, Pro, Gly, Leu, Phe and Trp; whereas AKH II had the following composition with each residue in almost equimolar amounts: Asp, Ser, Glu, Gly, Ala, Leu, Phe and Trp. Periplaneta americana CC extract showed two absorbance peaks with hyperglycaemic activity, which both had different retention times to those of locust AKH I and II. Carausius morosus CC extract revealed also two absorbance peaks with adipokinetic activity, the major one co-eluting with crustacean red pigment-concentrating hormone. However, it is clear from other experiments that both substances do not have the same structure.

## §5.1. INVESTIGATION ON A CRUSTACEAN HYPERGLYCEMIC HORMONE-LIKE PEPTIDE IN 38 THE CENTRAL NERVOUS SYSTEM OF THE LOCUST, LOCUSTA MIGRATORIA

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Located in the pars intercerebralis of the locust brain, approximately 50 neurosecretory perikarya contain a peptide with an epitope, recognized by an antiserum directed against the crustacean hyperglycemic hormone (CHH) of the crab, Carcinus maenas. Axons of these perikarya run through the neuropil to the corpora cardiaca. Immunoreactive axon terminals are present in the neurohemal organ, preferably in the close vicinity of the median cleft between the corpora. From isolated corpora cardiaca a peptide was isolated by a two-step purification procedure which consisted of gel chromatography on Sephadex G 50s followed by high performance liquid chromatography. The 5000 to 6000 Dalton peptide was detected by radioimmunoassay for Carcinus hyperglycemic hormone, although cross-reactivity with this neuropeptide is very low. In contrast to the hypertrehalosemic factor of insects, the CHH-like peptide is susceptible to heat denaturation.



55.1.  
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## PROPERTIES AND ACTIONS OF DIAPAUSE HORMONE IN BOMBYX MORI

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Diapause hormone is a neuropeptide hormone secreted from the suboesophageal ganglion and induces embryonic diapause in Bombyx mori. A lipophylic peptide fraction was extracted from the male adult heads and was purified into an almost single peak with a molecular weight of 3300 by a high performance liquid chromatography.

This hormone acts on developing ovaries of Bombyx mori to reduce cyclic GMP levels in 30 min after hormone treatment and then to enhance trehalase activity in a dose-dependent manner. The stimulated trehalase brings about a hyper-glycogenic state in the matured eggs and the following sorbitol formation at the initiation of embryonic diapause of this insect.

55.1.  
40

## CONTROL OF ENERGY METABOLISM IN ADULTS OF MANDUCA SEXTA DURING STARVATION

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In starving adult Manduca sexta fat body glycogen and haemolymph sugar level decrease strongly. The decrease of fat body glycogen is caused by an activation of fat body glycogen phosphorylase. The content of total lipids of fat body decreases too, while haemolymph lipid levels are increased. In starving larvae fat body glycogen phosphorylase is activated by "glycogen phosphorylase activating hormone" (GPAH) secreted from the Corpora cardiaca (1). In adults injection of extracts from the Corpora cardiaca activate fat body glycogen phosphorylase, but GPAH does not seem to be involved in this control in adults, as in starving cardiacectomized adults phosphorylase is activated like in control animals. Haemolymph lipid level in starved adults is also independent of hormones from the Corpora cardiaca, although in M. sexta there is an adipokinetic hormone which mobilizes lipids during flight (2). In adults activation of glycogen phosphorylase and mobilization of lipids seem to be controlled by the haemolymph sugar level. If sugar level is increased, glycogen phosphorylase is inactivated and haemolymph lipid level is decreased.

1) Siebert, K. and Ziegler, R.: Nature 301 (1983), 526-527

2) Ziegler, R. and Schulz, M.: Acta Endocrin. Suppl. 246 (1982), 32-33

**55.1.** STEROID AND PEPTIDE REGULATION OF MELANIZATION IN THE  
**41** TOBACCO HORNWORM LARVA

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Normally *Manduca* have a transparent larval cuticle. When juvenile hormone is absent at the time of head cap apolysis during a larval molt, the epidermis deposits premelanin granules containing an inactive prophenoloxidase into the newly forming body cuticle about 14 hrs later. The onset of melanization at 26 hrs (3 hrs before ecdysis) is cued by the decline of the ecdysteroid titer below a critical threshold level [250 ng/ml 20-hydroxyecdysone (20HE) equivalents]. *In vitro* experiments showed that as little as 50 ng/ml 20HE prevent melanization when the tissue is explanted before this critical time. The 20HE does not prevent uptake or incorporation of the melanin precursors, dopa or dopamine, into the epidermis. Its possible actions in delaying activation of the prophenoloxidase and the appearance of the precursors are presently under study. In contrast to body melanization, melanization and hardening of the head cap and "shields" on the prothoracic and anal terga occur just after ecdysis. Although dopa and dopamine are incorporated throughout the exocuticle as it is deposited, bursicon is required for melanization and hardening, both *in vivo* and *in vitro*. Thus two cuticular regions predisposed to melanize by the hormonal milieu early in the molt respond differently at the end of the molt--the flexible body cuticle requiring only the fall of ecdysteroid, the head requiring in addition a specific neuropeptide signal. Supported by grants from NSF and NIH.

**55.1.** NON ECDYSTEROID STEROIDS AND IMMUNOREACTIVE "VERTEBRATE-  
**42** TYPE" NEUROPEPTIDES IN DIFFERENT INSECT SPECIES

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By means of negative chemical ionisation-gas capillary chromatography-mass spectrometry more than 10 non ecdysteroid steroids have been identified in haemolymph of the fleshfly *Sarcophaga bullata* and the Colorado potato beetle, *Leptinotarsa decemlineata*. Radioimmunoassay is used to measure the concentrations of progesterone and testosterone. In the Crustacean *Astacus leptodactylus* female specific steroids occur. Analysis of the nature non ecdysteroid steroids present in adult *Locusta migratoria* and their function is in progress. By means of immunocytochemical methods, the presence in neurosecretory cells of numerous antigenic determinants with similar properties as those of "Vertebrate-type" neuropeptides has been demonstrated in *Periplaneta americana*, *Locusta migratoria* and two fly species.

**PS.- IMMUNOSUPPRESSIVE AGENTS OF MAMMALIAN TYPE HAVE NOT DEPRES-**  
**1 SSIVE EFFECT ON DEFENCE SYSTEM OF GALLERIA MELLONELLA PUPAE**

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Antimetabolites and cytostatics, known to inhibit the cellular defence in mammals, were injected once into haemocoel of lepidopteran pupae, either together with the inducer of immune response or 6 hr after. Nine hr after induction, pupae were challenged with 9, 10 or 11 viable cells of *Pseudomonas aeruginosa* for evaluation of the acquired resistance to the pathogen. Another set of the animals was bled for assay the level of blood lysozyme activity, nine and 18 hr after injection of the broth.

Inhibitors given via the proleg into insect haemolymph at a high dose but not toxic yet for pupae of the moth /ametopterin, 14.7; 5-fluorouracil, 15.0; cyclophosphamide, 15.5 mcg/ul/pupa/ have not depressive effect on the insect inducible defence system, independently if agent is given at time 0 or at the end of the lag period. Animals given a broth injection increase the level of lysozyme and, like pupae treated with the antimetabolite or cytostatics, survive the lethal dose of the pathogen while almost 100% of control unimmunized insects die with a typical sign of *P. aeruginosa* bacteremia. An anti-inflammatory drug, hydrocortisone hemisuccinate at doses of 12.5 mcg has a modest inhibitory effect, depressing both the increase of the level of lysozyme and the protective immunity against bacterial parasite.

**PS.- METABOLIC EFFECTS OF ANOXIA ON THE CNS OF THE HONEY BEE (APIS MELLIFICA)**  
**2 AND THE BLOWFLY (CALLIPHORA ERYTHROCEPHALA)**

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Adult insects have a high metabolic rate and they are specialized on aerobic energy production. They have been reported, however, to survive anoxic periods of many hours. This is surprising in view of the fact that adult mammalian brains will be irreversibly damaged after only a few minutes of anoxia. The experimental animals were kept under pure nitrogen for various time periods and metabolites of the cellular energy metabolism were determined in brain tissue by enzymatic methods: 1) In both species the high energy phosphates ATP and argininephosphate are not detectable after 30 min of anoxia whereas AMP and inorganic phosphate are elevated. 2) In the *Apis* brain glycogen decreases from an initial 15.7  $\mu\text{mol}$  hexose per g ww to 10.5 and 4.8 after 30 and 60 min resp. The corresponding values in *Calliphora* are 10.6, 4.9, and 3.5. Glucose and trehalose concentrations are not affected in the *Calliphora* brain, in contrast to *Apis* where an initial splitting of trehalose and a concomitant increase in glucose do occur. 3) As products have been detected glycerol, alanine, as well as some lactate in *Apis*; alanine, glycerol-3-phosphate and glycerol in *Calliphora*. Drawing up a balance sheet leads to the conclusion that additional products might be formed during anoxia. The results indicate a significant reduction of the metabolic rate in anoxic insects brains and a detour of the first, phosphorylating part of glycolysis.

Supported by Deutsche Forschungsgemeinschaft, Bonn, grant We 494/6

PS.-  
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### ANOXIC CO<sub>2</sub>-PRODUCTION OF THE LOCUST LOCUSTA MIGRATORIA

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Despite their specialization on aerobic energy production, insects are able to survive extended anoxic periods in a state of total paralysis.

In undissected locusts, in contrast to isolated anoxic ganglia, no significant change in brain glycogen and trehalose (24 and 18  $\mu\text{mol/g ww}$  as hexose resp.) could be detected during 3 hours in 100 % N<sub>2</sub> at 25 °C.

In order to describe the influence of substrate transport from other parts of the body, D-(U-<sup>14</sup>C)-glucose was injected into the abdominal hemolymph and the evolved CO<sub>2</sub> was determined. In aerobic controls, which show a well defined tissue distribution of the label, <sup>14</sup>CO<sub>2</sub>-production follows an exponential graph. After 3 hours 28 % of the injected <sup>14</sup>C-glucose is transformed into CO<sub>2</sub>, after 50 hours 28 % of the radioactivity can still be found in the animal.

Anoxia causes a standstill of the hemolymph flow; no transport of label to the head could be observed. When animals, after being injected with <sup>14</sup>C-glucose, were kept in air for various time periods and then subjected to total anoxia, they nevertheless produce a remarkable amount of <sup>14</sup>CO<sub>2</sub>, up to 60 % of the corresponding aerobic control values.

From these data we conclude that under sustained anoxia no substrate is transported to the brain by the hemolymph, but that material might be shifted from the head fat body to maintain brain energy metabolism, whose rate must be considerably reduced in anoxia.

Supported by Deutsche Forschungsgemeinschaft, Bonn, Grant We 494/6

PS.-  
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### ELECTROPHORETIC CHARACTERIZATION OF HAEMOLYMPH ESTERASES IN THE COCONUT PEST, ORYCTES RHINOCEROS.

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Isozyme pattern of haemolymph esterases of male and female Oryctes rhinoceros were characterized by inhibition/activation studies using polyacrylamide disc gel electrophoresis. Treatment with the detergent like sodium oleate, sodium lauryl sulphate and Triton X-100 increased the number of fractions. The reason for the observed phenomenon is discussed. Esterases fraction were more in female than that of the male. The significance of this was discussed. Based on the inhibitory effect on esterases isozyme fractions, the haemolymph esterases of male and female are probably carboxylesterase.

**P5.-**  
**5** EVALUATION OF INSECT PROTEIN AS ECONOMIC SOURCE OF PROTEIN FOR POULTRY

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Experiments were conducted to evaluate the efficiency of larvae of house flies as a source of dietary protein for broilers. The rate of growth was higher in chicks fed on diet containing larvae meal than in those fed on normal diet at 10<sup>th</sup>, 24<sup>th</sup> and 38<sup>th</sup> days of chicks age, while it was lower at 17<sup>th</sup> and 31<sup>st</sup> days age as compared with controls.

Feed consumption at 38<sup>th</sup> days of broilers age increased as a result of feeding them on diet containing larvae meal, while feed efficiency was not affected.

Shank and thigh lengths of chicks were highly significantly affected with the source of dietary protein. Chicks fed on diet containing larvae meal had higher shank length.

**P5.-**  
**6** COMPARATIVE MORPHOGENETIC EFFECTS INDUCED BY PRECOCENES ON DIFFERENT IMMATURE STAGES OF *Oxycarenus lavaterae* (F.)

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Morphogenetic effects induced by precocene 2 and Ethoxyprecocene 2, on 3rd, 4th or 5th instar nymphs of *Oxycarenus lavaterae* (F.) (*Heteroptera, Lygaeidae*), have been studied.

Compounds were applied topically at doses of 10, 5 or 1 µg. When applied on 3rd instar, precocious adults appeared at both 4th and 5th instars. Those of the 5th instar showed a high degree of uniformity and also more evident adultoid features, whereas precocious adults of the 4th instar exhibited a considerable variability and moderate adult characters. Fifth instar precocious adults obtained by treatment of 4th instar nymphs, showed similar characteristics as those 4th instar precocious adults described above.

Finally, treatment of newly emerged 5th instar nymphs induced the apparition of adultiforms with unexpanded wings, that can be envisaged as a juvenilizing-like effect.

P5.- THE SEASONAL DIMORPHISM OF A BUTTERFLY, ARASCHNIA LEVANA L.  
7 (NYMPHALIDAE), IN RELATION TO HORMONAL CONTROLLED DEVELOPMENT

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Araschnia levana represents a lepidopteran species with a facultative pupal diapause. The adults show different seasonal forms. Nondiapausing animals have almost black wings, while those, hatching from diapausing pupae have mainly red wings, due to ommochrome formation in the wing pigment cells. The combination of diapause induction with seasonal colour forms led to the question, whether the two processes are either expressions of the same physiological mechanism or independently determined in response to photoperiod. Insect diapause is controlled by hormones. The question is, whether the formation of different coloured forms is regulated in the same manner as diapause induction. This is investigated by examination of ecdysteroid and juvenile hormone titers, application and injection of these hormones and by parabiosis experiments. The hormone titers show the well known pattern for regulation of pupal development. JH application acts on larval-pupal-adult development, but not on the pigment formation. 1µg 20-OH ecdyson evokes development of diapause determined pupae and in addition has an effect on wing colouration. An injection at day one or two after pupation causes black coloured nondiapause adults, whereas the red coloured area of the wings increases, when the pupae are treated later. Parabiosis experiments confirm these results.

P5.- A CARDIOACTIVE NEUROPEPTIDE FROM MANDUCA SEXTA LARVAE.  
8

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A sensitive bioassay technique has been used to investigate the distribution, abundance and properties of an endogenous cardioactive small peptide in larvae, and other stages of the tobacco hornworm, Manduca sexta. Partial purification of the peptide has been achieved using reverse-phase HPLC.

PS.-  
9

AN IN VITRO SYSTEM TO STUDY THE INCORPORATION OF VITELLOGENIN INTO THE  
OOCYTES OF THE OVOVIVIPAROUS COCKROACH, NAUPHOETA CINEREA

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In order to investigate the mechanism of vitellogenin incorporation into oocytes and the importance of juvenile hormone in regulating this process we have developed a system for culturing oocytes in vitro. In this system single ovarioles are incubated in heat-treated cockroach haemolymph containing  $^{14}\text{C}$ -vitellogenin. After working up oocyte membranes and oocyte content separately the amount of vitellogenin incorporated is measured by liquid scintillation counting. Dilution of the  $^{14}\text{C}$ -vitellogenin by the vitellogenin present in the haemolymph used for incubation is determined using rocket immunoelectrophoresis.

Our data show that vitellogenin is incorporated specifically, since other  $^{14}\text{C}$ -labelled haemolymph proteins are hardly incorporated at all. Analysis of the oocyte content using PAGE combined with liquid scintillation counting indicates that the majority of radioactivity incorporated is identical to vitellogenin. Time-course studies show that vitellogenin uptake is linear for 12 h. Oocytes at the stage of most rapid growth incorporate approximately 3-4  $\mu\text{g}$  vitellogenin per 8 h. Vitellogenin incorporation is dependent on the oocyte maturation stage and increases with oocyte size until chorion formation, whereafter it ceases.

The use of this in vitro system should now allow us to investigate the precise role of juvenile hormone in regulating vitellogenin uptake.

PS.-  
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YOLK PROTEINS AND ECDYSTEROIDS DURING EMBRYOGENESIS  
IN THE STICK INSECT, CARAUSIUS MOROSUS

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In the stick insect Carausius morosus vitellin is composed of six subunits not forming an uniform protein molecule, but at least two different aggregates which can be traced until hatching. Some of the aggregates disappear from the egg at certain times of the embryonic development. To study the degradation of vitellin subunits, protease activity was measured during embryogenesis. Increased proteolytic activity could be correlated to stages, when vitellins are broken down.

One of the functions of the vitellin presumably is the storage of maternal ecdysteroid hormones since they cannot be synthesized by the embryo itself.

By RIA we could show that for the most part ecdysteroids from freshly laid eggs are bound to yolk proteins, preferentially to one of the vitellins. These ecdysteroids were analysed by various techniques. Parts of them are ecdysteroid conjugates.

To study their fate in the developing embryo we analysed the content of free and conjugated ecdysteroids during embryogenesis in relation to the degradation of yolk proteins.

**P5.-** JUVENILE HORMONE BINDING PROTEINS IN *SARCOPHAGA BULLATA*  
**11** VITELLOGENIC OVARIES AND HAEMOLYMPH.

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A juvenile hormone binding protein was demonstrated in extracts of vitellogenic ovaries of *Sarcophaga bullata*. PEG and DCC binding assays yielded a similar  $K_d$  value of  $1.5 \times 10^{-7}$  M for JH III. The order of binding activity is JH III > JH II > JH I > methoprene. A single JH binding peak with an apparent molecular weight of about 500,000 daltons was obtained on HPLC separation of ovarian as well as haemolymph proteins. The  $K_d$  value of the JH binder in the haemolymph was also found to be around  $1.5 \times 10^{-7}$  M. Total binding activity was however higher in the haemolymph than in ovarian extract. Previtellogenic ovaries show only very little JH binding. These findings suggest that the ovarian binding protein is taken up from the haemolymph during vitellogenesis.

**P5.-** OVARIES IMPLANTED IN MALE LADY BEETLES SYNTHESIZE  
**12** VITELLOGENIN

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To test whether the yolk protein precursor (vitellongenin) could be synthesized by ovaries of the lady beetle Coccinella septempunctata, we transplanted ovaries from newly emerged females into males, which normally do not produce this protein. During 30 days of in vivo incubation, the oocytes developed and accumulated yolk. A small number of oocytes developed to mature eggs complete with chorion, but the majority exhibited an intermediate stage of development. In vitro organ culture experiments demonstrated vitellogenin synthesis in the implanted ovaries, but not in the male host fat bodies, and no vitellogenin was detected in the hemolymph of the male hosts. Treating male hosts with juvenile hormone analogue ZR512 stimulated the development of the implanted ovaries, but did not induce vitellogenin synthesis in the fat bodies of the male hosts. Therefore it appeared that the yolk protein deposited in the transplanted ovaries came from the implanted ovary tissue itself rather than from the fat body of the male hosts.



**P5.-** JUVENILE HORMONE REGULATION OF OOTHECIN mRNA IN THE  
**13** LEFT COLLETERIAL GLAND OF A COCKROACH (*PERIPLANETA AMERICANA*)

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The synthesis of oothecins (small glycine-rich structural proteins of the cockroach egg case) has been shown to be dependant on the presence of juvenile hormone. Probes for oothecin mRNAs have been obtained from cloned oothecin cDNAs. These were used to quantitate the expression of specific oothecin mRNAs in the colleterial gland during its maturation and during hormonal withdrawal and replacement.

**P5.-** A COMPARATIVE ANALYSIS OF THE CONVERSION OF THE ECDYSTEROID PRECURSOR  
**14** 2,22,25-TRIDEOXYECDYSONE<sup>(1)</sup> ("KETODIOL") BY TWO ECDYSIOSYNTHETIC TISSUES  
IN *LOCUSTA* : THE PROTHORACIC GLANDS AND THE FOLLICLE CELL EPITHELIUM

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Studies with ovaries of vitellogenic females of *Locusta* have shown a few years ago that the 5 $\beta$ -ketodiol (2,22,25-trideoxyecdysone) can be considered as a biosynthetic intermediate between cholesterol and ecdysone in this biological model (Hetru et al, 1982). This molecule is also converted by prothoracic glands of *Manduca Sexta* to ecdysone, as shown by Bollenbacher and associates in 1977. A newly synthesized high specific activity 5 $\beta$ -ketodiol (107 Ci/mmol; Haag et al, 1984) has been used to investigate and compare the capacities of prothoracic glands, follicle cells, fat body, Malpighian tubules, etc, to hydroxylate this precursor at C-2, C-22 and C-25. The poster will present the principal results. A complex pattern of various hydroxylation sequences is evidenced, but only prothoracic glands and follicle cells converted the 5 $\beta$ -ketodiol to ecdysone in the experiments which we have undertaken so far.

<sup>(1)</sup> (22,23,24,25)-<sup>3</sup>H<sub>4</sub>-3,14-dihydroxy-5 $\beta$ -cholest-7-en-6-one synthesized by Haag T., Hetru C., Nakatani Y., Luu B., Pichat L., Rousseau D. and Meister M., submitted.

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C. Hetru, C. Kappler, J.A. Hoffmann, R. Nearn, L. Bang and D.H.S. Horn, *Molec. Cell. Endocrinol.* 26, 51-80, 1982.

W.E. Bollenbacher, M.N. Galbraith, L.I. Gilbert and D.H.S. Horn, *Steroids* 29, 47-63, 1977.

**PS-15** UTILIZATION AND METABOLISM OF DIETARY STEROLS IN  
SPODOPTERA LITURA (F.).

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The tobacco caterpillar, Spodoptera litura (F.) an important pest of a number of plants, was found to contain predominantly cholesterol (about 90%) followed by sitosterol and campesterol to a much lesser extent in different developmental stages and adults. Whereas one of the common host plant, Ricinus communis L., contained predominantly sitosterol (62.9%) followed by stigmasterol (23.4%), cholesterol (9.8%) and campesterol (3.8%). When the sixth instar larvae were given artificial diet containing  $^3\text{H}$ -sitosterol and  $^{14}\text{C}$ -cholesterol either separately or simultaneously in equimolar concentrations the absorption of cholesterol was about 10 times more than that of sitosterol. It was also shown that  $^3\text{H}$ -sitosterol was dealkylated to cholesterol by the fat body of Spodoptera. However, the pathway of this dealkylation in S. litura has not been studied as yet.

**PS-16** VITELLOGENIN OF THE GERMAN COCKROACH, BLATTELLA GERMANICA: STRUCTURE AND FUNCTION OF HIGH MANNOSE OLIGOSACCHARIDE IN SECRETION, UPTAKE AND STORAGE

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High mannose oligosaccharide (oligo) is found on secreted insect proteins including Vitellogenin (Vg). It is of general interest to know if oligo plays a role in ticketing of Vg during its journey from site of synthesis in maternal fat body to its utilization by developing embryos. All functions of oligo in insects must be accomplished within confines of a fairly simple composition and branching structure. The principal oligo of B.germanica Vg is  $\text{Man}_7\text{-GlcNAc}_2$ . Insects have no complex oligo and only limited processing of the high mannose type has so far been observed in insects. Microheterogeneity of Vg oligo includes presence of small amounts of  $\text{Glc-Man}_7\text{-GlcNAc}_2$ , representing uncleaved terminal glucose left over from *en bloc* transferred  $\text{Glc}_3\text{-Man}_7\text{-GlcNAc}_2$  and smaller amounts of other sized oligos down to  $\text{Man}_3\text{-GlcNAc}_2$ .  $\text{Man}_3$  oligo is enriched on the 50K Vitellin (Vt) subunit. Tunicamycin inhibits peptide cleavage and Vg secretion. Vt undergoes a trimerization during storage in oocytes covering up the uptake site by which the oocyte recognizes Vg or Vt for adsorptive endocytosis. Trimerization also covers up all oligo, freely accessible by alpha-mannosidase prior to trimer formation. Elimination or periodate oxidation of oligo on monomeric Vt, mannan coinjected with Vt, and proteolytic clipping of Vt, each inhibit Vt uptake into oocytes. The combined conformation of protein and oligo may play a direct role in specificity of the endocytotic process. Oligo may participate in the assembly or stability of Vt trimer since modification of the oligo by periodate oxidation causes trimer to fall apart. (supported by National Science Foundation grant, PCM-8204549).



Section 6 Ecology and Population Dynamics.....

R 6.1. Parasitism and Predation .....

R 6.2. Life History Strategies .....

R 6.3. Population Dynamics and Competition .....

R 6.4. Migration and Dispersal .....

R 6.5. Diapause and Cold Resistance .....

R 6.6. Ecology of Pest Insects .....

R 6.7. Ecology of Dung Beetles .....

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S 6.1. Interaction of Host Plant Resistance and Parasites and Predators of Insects .....

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P 6. ....

F 6. ....

## **R6.1.** THE FUNCTION OF HOST DISCRIMINATION IN PARASITOIDS: AN UNSOLVED RIDDLE **1**

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The function of marking parasitized hosts is generally considered to be the prevention of wastage of eggs by the ovipositing female. It is also often seen as a form of contest competition between different females of the same species that similarly refrain from oviposition in already parasitized hosts. In a number of cases host discrimination seems to be learned from experience.

In superparasitized hosts contest competition takes place between first instar parasitoid larvae. Scramble competition and wastage of food is prevented.

Usually, parasitoids of different species do not react to each other's mark.

If the advantage of avoiding wastage of eggs would be as high as supposed, why has natural selection not favoured interspecific host discrimination?

A number of possibilities will be discussed. For instance, if the first parasitoid is not always the winner of the contest in a superparasitized host, and host availability is low, it might pay to superparasitize.

Obviously, the main function of marking and discrimination is the maximisation of the reproductive success of the individual ovipositing and marking female.

## **R6.1.** SIGMOID FUNCTIONAL RESPONSES IN INSECT PARASITES AND **2** PREDATORS

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Though Type II functional responses for insect parasites and predators have been obtained from many laboratory studies, an increasing number of publications reports sigmoid functional responses for these invertebrates. Holling suggested that sigmoid functional responses are caused by learning: a change in behaviour when the predator experiences differences in prey density causes the density dependent predation. As behavioural changes that possibly cause sigmoid functional responses, density dependent changes in the giving up time, in the attack rate, in the handling time and switching have been proposed.

Here we show that parasites and predators do not have to change their behaviour to produce the sigmoid functional responses so far published.

R6.1. FORAGING FOR PATCHILY-DISTRIBUTED HOSTS BY THE BRACONID WASP,  
3 DACNUSA SP.

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Leaf mining hosts, Phytomyza ranunculi Schrank, are patchily distributed among leaves of host plants. It is important for the foraging efficiency how the female wasp of Dacnusa sp. allocates her foraging time among patches of hosts. We analyzed the determinants of the patch time which she spent searching hosts during a single visit to the leaf. The wasp discriminated between presearched and unsearched leaves, probably by perceiving some trail (probably volatile substance) left by herself on leaves and did not stay so longer on the former leaves. The trail will be one of determinants for the patch time as well. On the other hand, when visiting the leaf not infested by hosts, the wasp did not stay on it so longer likewise. The encounter with mines made in the leaf by hosts would accelerate her searching movement on the leaf. From the viewpoint of the responsiveness of the wasp to those two factors, we discuss how the patch time of this wasp is determined in the course of searching hosts on the leaf.

6

R6.1. PARASITOID SEX RATIOS, MATING STRATEGIES AND MALE LONGEVITIES  
4

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Among hymenopterous parasites, where males contribute little to future generations other than sperm, evolutionary processes have shaped a number of distinct patterns which optimize population success. Two important features are sex ratio and male longevity relative to that of the female. Using parasitoids representing several families as models, clear patterns of species showing a high female bias, short lived males, and inbreeding are contrasted with species showing equal sex frequency, equal male-female longevity, and apparent outbreeding. The evolutionary significance of male strategies among these species will be discussed.

**R6.1.** LIFE HISTORY STRATEGIES OF PARASITIDS OF RUSH-FEEDING  
**5** COLEOPHORA SPP.

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In central Europe 20 species of parasitoids (Hym.:Ichneumonidae, Braconidae, Chalcidoidea) attack the common rush-feeding case-bearers, *Coleophora alticolella* Zeller and *C. glaucicolella* Wood. A four-year study of their parasite complex has been made in Germany, Switzerland and Austria. The structure of the various guilds of parasitoids (specific synchronized endoparasites of young and of full grown larvae; more polyphagous, less synchronized ectoparasites; and hyperparasites) and their competitive interactions and strategies for coexistence are discussed.

**R6.1.** PARASITOID COMMUNITY CENTRED UPON THE BIRCH SEED GALL MIDGE  
**6** *SEMUDOBIA* KIEFFER (DIPTERA: CECIDOMYIIDAE)

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Two species of *Semudobia* cause galls in seeds of *Betula* but differ in preference regarding their hosts, two sympatric species of birch. Interspecific competition is obviously not the driving force to maintain the midge species in different parts of resources, because a shortage (of food, shelter) is absent. However, such a force might be realized by parasitoids, if they respond population density of hosts and if host species specificity is present.

Four genera of hymenopteran parasitoids are specialized on different immature stages of *Semudobia*. Parasitoids of early larval stages (*Lioterphus* and *Tetrastichus*) exhibit strict host species specificity, whereas parasitoids of eggs (*Misocyclops*) and mature host larvae (*Psilonotus*) are aspecific or have only some preference. A key-factor analysis demonstrated that all parasitoids react density-dependent ( $r \approx .75$ ). The effect is most distinct ( $r \approx .50$ ) for *Psilonotus*.

**R6.1.** 7 Studies in population ecology of *Giraudiella inclusa* Fr. (Diptera: Cecidomyiidae) and its parasitoids on common reed (*Phragmites australis* (Cav.) Trin.)

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Reed stands harbor a multitude of phytophagous arthropods.

Interspecific competition is minimized by specialization on definite locations and definite parts of the reed, i.e. on compartments in space.

Based on life-table-dates for *Giraudiella inclusa* and its key-parasitoids the specific exploitation of their food-resources and some competition evasion strategies are characterized.

Concentrated infection in space and time of the phytophagous *Giraudiella* just as its entomophagous enemies are described along with aspects of the parasitoid-coexistence.

**R6.1.** 8 Hymenopteres Parasites et Hyperparasites de Schizaphis graminum Rondani, sur Sorgho, dans la Drome, de 1976 a 1982.

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De 1976 a 1982 l'importance et l'efficacite des parasites du Schizaphis graminum Rondani furent etudiees sur culture de Sorgho dans le Sud-Est de la France (departement de la Drome). Dix parasites primaires furent inventories: Aphidius uzbekistanicus Luzhetzki, A. rhopalosiphi Stary, A. matricariae Haliday, A. picipes Nees, A. ervi Haliday, Praon gallicum Stary, P. volucre Haliday, Ephedrus plagiator Nees (Aphidiidae), Aphelinus asychis Walker et A. varipes Foerster (Aphelininae, Encyrtidae). Dix especes d'hyperparasites (Cynipidae, Megaspilidae, Pteromalidae, Encyrtidae) reduisaient fortement l'efficacite des parasites primaires du S. graminum. Le taux de parasitisme annuel par les 4 grands groupes d'auxiliaires (Aphidius spp., Ephedrus, Praon spp. et Aphelinus spp.) restait assez faible tout le long de la saison dans ce departement. Parmi les 39000 pucerons momifies envoyes aux Etats-Unis dans le cadre d'un programme de lutte biologique contre le greenbug (S. graminum), seul Aphelinus asychis parassait definitivement etabli.



**R6.1.** EFFECTS OF PLANT RESISTANCE TO CEREAL APHIDS ON THE  
**9** PARASITISM BY APHELINUS ASYCHIS ON OATS

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Two of three oat varieties were proved to be partially resistant to the cereal aphids, *Macrosiphum avenae*, *Metopolophium dirhodum* and *Rhopalosiphum padi*. Comparison of the nutrition value of the aphids on these oat varieties for the parasitoid, *Aphelinus asychis* revealed differences in adult weight and sex ratio in the F1 generation. However, longevity and fecundity of the adults were not affected, if sufficient aphids and honeydew were supplied.

Plant resistance - aphid - parasite interactions were furthermore investigated under different initial population densities of both, aphids and parasites in laboratory.

Field experiments in 1983 showed that there were always fewer aphid mummies on the resistant varieties than on the susceptible one.

**R6.1.** THE ICHNEUMONIDAE (HYMENOPTERA) OF THE OJCÓW NATIONAL  
**10** PARK

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The incidence of Ichneumonidae in 8 main plant communities of the Ojców National Park was analysed. A total of 304 species, including 21 new to Poland, were stated. The richest in Ichneumonidae species proved to be plant communities *Fagetum carpaticum* (70 species) and *Tilio-Carpinetum* (79 sp.). In least amounts they occurred in plant communities *Origano-Brachypodietum* (30 sp.), *Lollio-Cynosuretum* (31 sp.) and *Pino-Quercetum* the *Pinus silvestris* variant (42 sp.). A species composition of Ichneumonidae in particular plant communities was very specific. A degree of similarity for Ichneumonidae between forest communities, expressed with Jacard's coefficient averaged 13%, reaching a maximum of 22%. However, a degree of similarity between forest and nonforest communities has hardly attained a value of 5%, assuming a maximum value to be 10%.

R6.1.

11

## Studies of Tachinid Flies in China

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In order to augment the utilization of tachinid flies in biological control we have been working on the following problems: 1) Faunistic investigation on the useful species in China although there are about 500 identified species of tachinid flies parasitizing insect pests hitherto, only a few of them are capable of suppressing the pest population to a significant degree. Some examples are given indicating that the ability of the tachinid flies to control the pest varies with the species. 2) Modes of parasitism and biological characters Various modes of parasitism are observed in China according to the differences of breeding habits and all of which are the results for a long time. 3) Adaptation to hosts The adaptation of tachinid flies to their hosts are also the results of evolution through a considerable period of natural selection. 4) Studies on mass-rearing of some species of tachinid flies Lydella grisescens R-D and Sturmia inferens Townsend, whose larvae can make active searching after their hosts are being reared by using natural and factitious hosts.

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R6.1.

12

"ON TWO NEW DISEASES CAUSED BY PROTOZOAN PARASITES IN THE NATURAL POPULATION OF ORYCTES MONOCEROS OL. IN TANZANIA"

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Oryctes monoceros Ol. is a major pest of coconut palms in Tanzania. Except for some eugregarines living as commensals in the gut of rhinoceros beetles reported by Huger (1967, 1968) and Monsarrat (1969) there are no data in the literature concerning the diseases caused by protozoan parasites. A recent survey on the larvae and adults of O. monoceros in Tanzania has revealed the presence of two new protozoan species (one neogregarine and one microsporidium) causing lethal effects to their hosts. The names, Ophryocystis oryctesi n. sp. (Neogregarinida, Ophryocystidae) and Nosema tanzaniae n. sp. (Microspora, Microsporida) are proposed for them. The invaded organs: Malpighian tubules (neogregarine) and midgut-epithelium (microsporidium) appeared hypertrophied, transparent and milky-white. In case of heavy infection they were totally destroyed. The life cycles of neogregarine and microsporidium are described by means of light- and electron microscopy. The host-parasites relationship, prevalence of infections and the importance of the parasites for biological pest control will be discussed.

R6.1.  
13

THE INCIDENCE AND SEASONAL PREVALANCE OF DISEASES OF  
SILKWORM, BOMBYX MORI L. IN BANGLADESH  
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The mulberry silkworm, Bombyx mori L. has become domesticated for many centuries. They are by nature quite delicate and highly sensitive to environmental conditions like diseases and parasites. The major diseases of silkworm in Bangladesh are pebrine, muscardine, flatcherie and polyhedrosis. In the present study, it was observed that the intensity of different diseases varied from season to season and race to race. Among 5 rearing seasons of the year, July-August showed the highest intensity of infection followed by September-October, May-June and lowest in January-February. The incidence of diseases has direct correlation with temperature and relative humidity. Early instar larvae were more susceptible than the later instar larvae. Indegenious races were more resistant than introduced races and hybrids.

R6.1.  
14 PREY KILLS PREDATOR! — COUNTERATTACK OF TETRANYCHID MITE AGAINST  
PHYTOSEIID PREDATOR —

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Spider mite prey and phytoseiid predator are good materials to study prey-predator interactions. Recently it has been known that spider mite possess various defense mechanisms due to their webbing habits against predators. However, in prey-predator systems, in general, defense and/or escape behaviours of prey usually function only to lower the probability of death by predation.

In the present study, I discovered an amazing and interesting phenomenon, i.e., counterattack of prey against predator. The spider mite, observed, *Schizotetranychus celarius* (Banks), lives under a self constructed woven nest on a bamboo leaf together with its family. *Typhlodromus bambusae* Ehara is a specialized predator which invades *S. celarius*'s nest. Results of the experiments were as follows. 1) *S. celarius* (hereafter called 'prey') adults vs. *T. bambusae* (hereafter 'predator') adults The prey females and males in the nest escaped, leaving their offspring, when the nest was invaded by predator adults. 2) Prey females vs. predator larvae or protonymphs The prey females attempted to evict the predators from their nest. The immature predators were killed by the prey females on rare occasions. 3) Prey males vs. predator larvae or protonymphs When a male (or males) was present in the nest, the invaded predators were often killed by him. On this occasion, the prey male(s) was seldom killed, and he repeatedly counterattacked against the intruders. I concluded that there is a special kind of parental care in *S. celarius*. The background of this behaviour will be discussed in relation to the population phenomena.

**R6.1.** INFLUENCES OF FOOD RESOURCES AND TEMPERATURES ON LIFE CYCLE,  
**15** PREDATION, AND LIFE PARAMETERS OF PREDATORY MITE, A. ovalis

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Rep. of China

The life cycle, predation, and population increase of Amblyseius ovalis was studied on a modified floating leaf culture with prey mites of either Eotetranychus boemeriae, or Eutetranychus orientalis, or Oligonychus mangiferus, or Oligonychus biharensis, or Panonychus elongatus, or Tetranychus kanzawai, or maize pollens at different temperature regimes. The duration of the predators' developmental rate, fecundity, and prey consumption varied significantly as food resources of A. ovalis changed. The highest developmental and reproductive rates of A. ovalis was found in predator population feeding on O. mangiferus and maize pollen at 30°C. And the population possessed a capacity to double itself within 1.87 days. However, intrinsic rate of natural increase ( $r_m = 0.255$ ) of A. ovalis feeding on O. mangiferus at 25°C was the highest among all tested food resources and temperature regimes. A critical minimum temperature required for development and reproduction of A. ovalis was estimated from the responses of A. ovalis to different temperature regimes and two most preferable food resources. From the best fitting of logarithm linear regression model with 0.999 of square of correlation, the minimum temperature was 13.5°C for development and reproduction of A. ovalis.

**R6.1.** A SIT-AND-WAIT PREDATOR ATTACKING ASSEMBLAGES OF APOSEMATIC PREY  
**16**

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Rhinocoris punctiventris (H-S) (Hemiptera: Reduviidae) were significantly more likely to be found on open flowerheads of Echinops viscosus (D.C.) (Compositae) in large groups of open flowers rather than single flowerheads. The open flowerheads were usually packed with great numbers of feeding Melyris bicolor Fabr. (Coleoptera: Melyridae). This aposematic beetle is distasteful to avian insectivores. Individual R. punctiventris were feeding on M. bicolor. Aposematic animals usually can aggregate more safely than can cryptics at reliable, concentrated resource bases. On the other hand, predators resistant to the noxious qualities of the aposematics can take advantage of this assembling quality.

**R6.1.** PREDATION BY TOXORHYNCHITES LARVAE (CULICIDAE) IN VENEZUELAN  
**17** PHYTOTELMATA

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First-instar larvae of native Toxorhynchites haemorrhoidalis mosquitoes were released into natural aquatic microhabitats: Heliconia flower bracts, bromeliad leaf axils, and bamboo internodes during wet and dry seasons in lowland tropical rain forest in eastern Venezuela. Insect communities in these habitats are dominated by dipterous larvae, but some include also coleopterous adults and larvae, and zygopterous larvae. Predator survival and potential prey abundance and diversity were compared between experimental and control phytotelm communities by complete sampling of the microhabitats at 10-day intervals. Predatory larvae were most successful in structurally less complex microhabitats, and success was influenced by prey availability and by competition with other predators. The impact of predation by T. haemorrhoidalis is discussed in relationship to season and to the role of other predators.

**R6.1.** PREDACEOUS INSECT FAUNA AND ITS ROLE IN REDUCING FLY POPULATION  
**18** IN ISOLATED CATTLE DROPPINGS IN PAKISTAN

R.K. SIDDIQUI AND A.I. MOHYUDDIN

Predaceous fauna in cattle droppings chiefly consists of staphylinids, hydrophilids, histerids and carabids. Different species attacked the immature stages of flies in a definite sequence.

The common species of flies breeding in droppings are Musca spp., Orthellia spp. and Sepsis spp. which start oviposition, as soon the droppings are deposited and continue laying for 3-4 days.

The first to reach dung are staphylinids, Philonthus spp., Thyreocephalus spp. and Aleochara spp. and hydrophilids, Sphaeridium spp. and Cercyon spp. The adults and larvae of staphylinids feed on eggs and most of them leave the droppings when fly larvae have hatched. By this time hydrophilids have hatched and they start feeding on fly larvae.

Histerids such as Hister spp. and Atholus spp. come next when the flies oviposit in crevices of drying dung. The adults and the immature stages feed on all stages of flies including full-grown larvae and pupae.

Carabids such as Scarites spp. Harpalus spp. are the last to come to the semi-dried droppings when the full-grown flies larvae start leaving dung for pupation. These also feed on fly puparia and other soft bodied insects beneath the droppings.

R6.1.

19

SELECTION AND PROVISION OF LARVAL PREY BY SCELIPHRON VIOLACEUM

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Sceliphron violaceum oviposits along with paralysed spiders inside a hole of electrical sockets. Oviposition behaviour of the wasp population over 2 years showed that it provides spiders weighing  $199 \pm 16$  mg/larva. Spiders belonging to the genera Argiope, Nevscona and Latrodactus are selected. During the summer months, a large number ( $40 \pm 6$ ) of smaller ( $5 \pm 1$  mg) spiders are selected; a fewer ( $23 \pm 7$ ) but larger ( $9.5 \pm 3$  mg) spiders are selected during monsoon. The wasp quantifies the spiders gravimetrically with an 8 % accuracy; at a given time, it can carry a spider weighing 87 % of its own body weight. Paralysed spiders of conspecific females are distinguished. The wasp has the ability to count by addition not by subtraction.

6

R6.1.

20

## REVIEW OF THE KNOWLEDGE OF THE ETHOLOGY OF SOLITARY ACULEATE WASPS OF THE AFROTROPICAL REGION

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Knowledge of the ethology of solitary aculeate wasps of the Afrotropical Region prior to the onset of the investigations by the present authors in 1972 was very limited. The most noteworthy studies on the subject were those of Brauns (1910/11) in the Cape Province of South Africa, Bequaert (1918) in the Belgian Congo (now Zaire), Smithers (1958) in S. Rhodesia (now Zimbabwe) and Bowden (1964) in Uganda. However, with the exception of the three species studied by the last two authors, most species were dealt with rather superficially and sometimes inaccurately. If it is considered that the Sphecidae (sensu lato) alone is represented in the region by no fewer than 81 genera and nearly 1 300 described species it will be obvious that there is an immense and exciting field for investigation. The present authors have concentrated their efforts to date in one limited area in karroid vegetation near Grahamstown in the Eastern Cape Province of South Africa. A study of the community structure of about 200 species of wasps (and about 50 species of associated bees) has been published as have been detailed studies of the ethology of in excess of 20 species. Present knowledge is reviewed and the contribution by recent studies to the extension of perspectives in a world context is assessed and discussed.

**R6.1.** THE ECOLOGY AND LIFE HISTORY OF NEW ZEALAND'S TIGER  
**21** BEETLES (COLEOPTERA: CICINDELINAE)

R. ANTHONY SAVILL

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Despite its comparatively small size New Zealand is a landmass of great ecological variety. Its thirteen species of endemic tiger beetle have evolved to occupy a wide diversity of habitats such as grasslands, riverbeds, beaches, mountains and forest. In adapting to these varying habitats many aspects of their bionomics and life history are unique.

**R6.2.**  
**1** CAN PLANTS REGULATE THEIR INSECT CONSUMERS?

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The population dynamics of insect primary consumers is clearly an ecosystem level process. The role of plants in this process is only poorly understood but evidence is mounting to suggest that they can significantly contribute to the regulation of insect populations. Regulation is accomplished through the manipulation of insect behavior and physiology. Manipulation is accomplished by rapidly changing plant traits. Such changes can occur spontaneously and in reaction both biotic and abiotic inducing factors. The plant, in collusion with natural enemies of insects, may be successful in most years in regulating insect numbers below densities that are detrimental to the competitive abilities of individual plants. Tolerance or evolved compensatory growth response to herbivory is part and parcel of the regulatory process.

R6.2.  
2

OFFENSIVE-DEFENSIVE INTERACTIONS  
BETWEEN INSECTS AND PLANTS.

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A consideration of known defensive attributes of plants and others that can be reasonably postulated, suggests that there may be two alternative attack strategies in herbivores, termed Stealth and Opportunism, respectively. Stealthy herbivores possess adaptations to minimize their impact on plant fitness and suppress induced defensive responses in plants. Opportunists take advantage of circumstances, such as physical stress or loss of acquired immunity in plants, which impair plant defensive capability. Opportunists also use adaptations which stress food plants. Herbivorous insect species with low, relatively invariant population levels may be Stealthy, whereas those with variable population levels may be Opportunistic. Phase polymorphism may be due to transition between the two strategies. It is suggested that interactions among herbivore species are better understood in terms of interference and facilitation than in terms of competition.

R6.2. FACTORS INFLUENCING THREE-TROPHIC-LEVEL INTERACTIONS BETWEEN WILLOWS,  
3 PONTANIA SAWFLIES, AND ENEMIES

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Three-trophic-level interactions are important in understanding host selection by herbivores. We have found that many traits of leaf gall-forming Pontania sawflies, their willow host plant (Salix lasiolepis), and Pontania enemies (parasitoids and inquilines) are interactive. There is significant variability both between and within willow clones in galling densities, sawfly survival, and enemy attack. Mechanisms of the interactions were studied using field experiments coupled with observations on natural populations. We tested five hypotheses relating to possible mechanisms influencing these three-trophic-level interactions: (1) The roles of host plant phenology, gall and sawfly development phenology, and enemy attack phenology; (2) Within and between willow clone variation in gall sizes and gall (and sawfly) developmental rates; (3) The effects of host plant vigor; (4) The effects of microsite variation; and (5) Variation in host plant chemistry. The relative importance of the various factors tested is discussed.



**R6.2.**  
**4**

SEASONAL PHENOLOGY AND LIFE HISTORY PATTERNS OF TROPICAL  
PIERID BUTTERFLIES

R. E. JONES

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Six species of pierid in the Australian tropics have been studied. Three are specialist herbivores of the same annual host plant; the remainder have a wide host range. Two of the specialist species and one generalist spend the dry season (winter) in an adult diapause. The others have no diapause and their distribution shifts seasonally, taking advantage of geographic variations in the growing season of their host plants. Developmental rates and body size of different species appear to be correlated with the size of typical host plants.

Developmental thresholds are higher, and the range of temperatures tolerated tends to be narrower, than comparable temperate species. There are also differences in reproductive behaviour. Similar patterns may occur in other butterfly families. There appear to be characteristic differences between tropical species and their temperate counterparts, whose adaptive significance is not always evident.

**R6.2.**  
**5**

GEOGRAPHIC DIFFERENCES IN FOODPLANT UTILIZATION ABILITIES OF  
LEPIDOPTERA: PHYSIOLOGICAL AND GENETIC MECHANISMS

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The central theme in our research concerns the differential suitability of various plants as hosts for the Papilionidae and Saturniidae (Lepidoptera) families. Of primary importance is the continued study of the behavioral/physiological/genetic bases and ecological significance of feeding specialization, with special concern for geographic variation in foodplant utilization abilities. The "feeding specialization hypothesis" is based on the presumption that diet specialization mediates an ecologically superior or metabolically more efficient utilization of food resources than polyphagy. Our recent efforts have focused upon biochemical/physiological adaptations both within and between individual Lepidopteran larvae, as well as within and between populations and species. Our inter-population and hybrid crossings and mass-rearing of thousands of individuals of Papilio, Hyalophora, and Callosamia species and subspecies through several generations, has provided us with a valuable data base which permits quantitative genetic analysis of several life history traits (e.g. morphology, size, color traits, diapause biology, and reproductive capacities) as well as differential foodplant detoxication/utilization abilities. Our focus has primarily been upon the physiological, phytochemical and genetic bases of geographic variation in foodplant utilization abilities of these Lepidoptera.

R6.2.  
6

r AND K REPRODUCTIVE STRATEGIES IN APHIDS

Dr M LLEWELLYN and Dr VK BROWN

Queen Elizabeth College and Imperial College, University of London

Species in the **Family** Aphididae vary from highly polyphagous to monophagous and feed from a wide range of angiosperms. Embryo number was used as an index to compare the reproductive strategies of over 100 species living on annuals, perennials, shrubs and trees throughout the season. Changes in strategy brought about by ant attendance, holocycly, anholocycly and host alternation were also investigated. A general relationship between aphid size and reproductive potential is explored and its value assessed.

R6.2.  
7

VARIATION IN FORM OF EARIAS INSULANA Boisd (Mepidoptera)  
ecological and physiological adaptation  
KASCHEF A.H. & ENAN R.A.

Colour variation in Earias Insulana Boisd is mainly due to both ecological and physiological factors. Temperature adaptation has been observed in differences in enzyme's activity as well as changes in concentration of nucleic acids, proteins and amino acids. The green form whose colour is composed of blue bile pigments and yellow caretenoid pigments, appeared dominating at high temperature (30°C) and different photoperiods. The insects were really active and the activity of many enzymes (lehydrogenases, phosphatases, cholinesterases,...) was of a high level. Concentration of ribonucleic acid and protein was relatively low. At low temperature (20°C) pigments responsible for yellow colouration (xanthopterine) increased leading to domination of the yellow form, Earias anthophilana at different photoperiods and fed on different types of food. Lower insect activity was accompanied by lower enzyme's activity. Concentration of ribonucleic acid and protein were relatively high, whereas 13 amino acids were present in higher levels than at 30°C.

**R6.2.** GEOGRAPHIC VARIATION AND SEASONAL REGULATION OF LIFE CYCLE IN  
**8** *CHRYSOLINA AURICHALCEA* MANNERHEIM (COLEOPTERA: CHRYSOMELIDAE).

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*Chrysolina aurichalcea* is a common species in the Japanese Islands. Since the detailed seasonal cycle, however, remains unknown, the present study attempts to describe it, to detect the regulation mechanism which causes it, and furthermore, to consider questions of geographic adaptation. Rearing experiments under various constant environmental conditions have revealed the following facts.

The species has a univoltine life cycle in all the Islands (Lat. 27°—45°N). The seasonal cycle is nearly constant in a specific locality but varies very much according to geographic location, i.e. at the southern end of the Islands, the breeding season is in winter, in central Islands it is from late autumn to early winter, while at the northern end and at high altitudes (e.g. 2000m in central Islands), it is from late summer to early autumn. The adult and egg diapause cause the regulation of the seasonal cycle and the geographic variation of diapause intensity results in the geographic variation of life cycle.

Finally, from these results and other eco-physiological information, the ecological significance of the seasonal cycle and geographic adaptation of the species will be discussed.

**R6.2.** ECOLOGY OF FUNGUS FEEDING DIPTERA AND THEIR PARASITES  
**9**

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The sporophores of fungi like the common *Megacollybia platyphylla* (Fr.) (Tricholomataceae) represent an unpredictable resource in space and time for fungus gnats. Fungivorous Diptera and their parasites show special developmental and reproductive strategies as an adaptation to this type of resource. Since 1982, single sporophores of *Megacollybia* were collected and examined with regard to infestations by dipterous larvae and their parasites. Seasonal and spatial niches of host and parasites are discussed.

R6.2.  
10

## THE IMPORTANCE OF CANNIBALISM TO AN INSECT HERBIVORE

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Larvae of the cabbage butterfly Pieris rapae are egg cannibals, whose impact on egg numbers depends on instar-specific voracities and distributions on the plant. The effect of egg cannibalism appears to be selectively neutral for the cannibal at the individual level; cannibalism generally decreases the probability of larval survival; but in some circumstances may produce compensatory increases in developmental rate and adult size (and hence fecundity). There is no significant individual competitive advantage from cannibalism. There is however a substantial group advantage, and the observed level of cannibalistic activity appears to maximize the benefit to the group.

6

R6.2.  
11

## EVOLUTION OF DIURNAL RHYTHMS OF ACTIVITY IN INSECTS

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Arthropods inhabiting moist substrates may be active almost continuously. Their emergence is limited by the daily range of air humidity. The best time for such emergence is the night. Adaptations to dry air prolong the activity outside the substrate. But the flying insect needs a visual orientation. If the insect has primitive eyes, it usually flies only in daylight. Improvements of eyes prolong the time of the flight activity. Therefore the night flight activity is not primary.

Biological clocks (endogenous rhythms) give an opportunity to foreknow the daily changes of conditions especially in insects that use shelters. If the insect does not use shelters, it usually has no expressed endogenous rhythms of activity.

The general tendency of rhythm evolution is a "conquest" of the time and maximal independence of environmental conditions.

**R6.2.** CO-PHENOLOGY OF PLANTS AND ENTOMOPHILOUS INSECTS IN A LIMESTONE GRASS-  
**12** LAND: ATTEMPT OF A HISTORICAL-AREA GEOGRAPHICAL INTERPRETATION

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The limestone grasslands (Mesobrometum) in southwestern Germany are characterized by a high percentage of submediterranean and subcontinental plant and animal species. A phenological analysis (flowering times of entomophilous plants, flight activities of Hymenoptera Apoidea and Lepidoptera) yields four seasonal periods named by the area geographical centre of their species: eurosiberian period (March, April), submediterranean p. (May, June), eurosiberian p. (July), eurosiberian p. with subcontinental and submediterranean elements (August, September). Vegetation, Apido- and Lepidofauna of the same area type correspond in their phenology (co-phenology). The flower-visiting insects of the studied area prefer plants of the same geoelement. It is shown that the history of the flora and fauna is important in the interpretation of the flower-visitor communities.

**R6.3.**  
**1** TWO NEW METHODS FOR THE STUDY OF INSECT POPULATION ECOLOGY

HSIN CHI and HSI LIU

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Based on the stage-frequency distribution, a multiple column matrix was used to express the age-stage-structure of animal populations with metamorphosis. Using this new method the growth process of insect and mite populations (both female and male were included) can be studied with proper stage grouping. Computer simulation demonstrated the usefulness of this method.

For the in situ study of field population ecology, a multidimensional matrix was used to display the spatial distribution of host plants and pest population. A large computer program (FDMSLBH) was designed to simulate the changes of pest population and host plants in a field. These methods made a way to approach to the agroecosystem simulation.

**R6.3.** A POPULATION MODEL FOR TWO-SPOTTED SPIDER MITE, TETRACHYUS  
**2** URTICAE AND ITS PREDATOR AMBLYSEIUS LONGISPINOSUS

SUEY-SHENG KAO<sup>1</sup> and W. Y. SU<sup>2</sup>

1. 189 Chung Cheng Rd., Wufeng, Taichung Hsien, Taiwan, R.O.C. 2. same as 1.

To better understand the interaction between Tetrachynus urticae and Amblyseius longispinosus, a temperature-dependent simulation model was proposed. Parameters for pest increase rate (q), natural enemy increase rate (p), and daily reduction (k) were derived from the life history and predation data of Lo and Ho (1979). These parameter's can be formulated into several temperature-dependent functions:

$$p = 0.61610 + 0.02646t$$

$$q = 0.63111 \text{ Exp } 0.02832t \quad \text{where } t : \text{temperature}$$

$$k = 2.99642 + \ln t$$

The pest population densities can be calculated by the equation:

$$a_{n+1} = a_n (0.63111 \text{ Exp } (0.02832t) - (2.99642 + \ln t)(0.61610 + 0.02832t))^{11}$$

Giving initial pest population and temperature, this model predicts the population densities of T. urticae at presence of A. longispinosus and gives the peak population density, peak day and controlled day by computer simulation.

**R6.3.** MODELLING POPULATION GROWTH OF GREENHOUSE WHITEFLY  
**3** (TRIALEURODES VAPORARIORUM) ON TOMATO.

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<sup>2</sup>Dept.of Entomology, Agricultural Univ., Wageningen, The Netherlands

For years Trialeurodes vaporariorum (Westwood) is an important pest on many cultivated crops, including tomato grown under glass. In view of its control, much research has been done on this pest. To make a synthesis of the results obtained by several research-workers, a computer simulation model including temperature-dependent rates was constructed. Some necessary but missing data were supplied by own experiments.

The state-variable model was verified by comparing simulation results with independent data from experiments conducted under semi-practical conditions.

Sensitivity analysis showed the relative importance of the rates and parameters included.

**R6.3.** LARGE-SCALE STUDY ON THE POPULATION DYNAMICS OF THE WHITEFLY  
**4** TRIALEURODES VAPORARIORUM (WESTWOOD) AND ITS PARASITE ENCARSIA FORMOSA GAHAN.

M.H.EGGENKAMP-ROTTEVEEL MANSVELD&J.C.VAN LENTEREN

1)Zoöl.Lab.,Division of Ecology,P.O.Box 9516,Leiden,The Netherlands

2)Dept.of Entomology,Agricultural Univ.,Wageningen, The Netherlands

The greenhouse whitefly Trialeurodes vaporariorum(Westwood), an important pest of several glasshouse crops is successfully controlled by the parasite Encarsia formosa Gahan. The changes in numbers and distribution of this host and parasite were followed over a period of sixteen weeks in a commercial glasshouse with 18.000 tomato plants. Both absolute counts and random samples were carried out. The data of the absolute counts revealed that the distributions of whitefly and parasite were clustered, though they changed gradually towards a regular pattern. This was caused by a strong migration of the whitefly-adults. The parasites have a very good capacity for migrating and searching. Further we tested Huffaker's 1958 hypothesis that a long-term coexistence of predator and prey is possible only if special requirements of space and dispersal of both prey and predator are fulfilled. The data of the random sampling program of 0.5% appeared to be very unreliable for estimating whitefly and parasite numbers and distribution. We are now studying efficient sampling methods to aid the growers in determining the whitefly infestation easily.

**R6.3.** STRUCTURE AND DYNAMICS OF MEDITERRANEAN FRUIT FLY POPULATIONS IN  
**5** HONOLULU, HAWAII

ERNEST J. HARRIS

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Honolulu, HI 96804

This paper uses life table parameters and survey methods to analyze and characterize the population dynamics of the medfly. Interpretation of the results focuses on behavioral adaptation and reproduction strategies of the medfly in dry urban areas.

### R6.3. POPULATION DYNAMICS OF DENDROPHAGOUS INSECTS

#### 6 ON TREE-LINE OF NORTHERN OB REGION

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In 1970-83 the insects groupings connected with main trees and shrubs of Jamal forest tundra were investigated. At this region some homopterans only have 2-3 generations in their yearly cycles and sometimes exhibit density outbreaks which were not found for leaf-gnawing insects. They consume an insignificant portion of their food plant leaves, no more than 10-15%.

Leaf-gnawing insects having high and constant density level are species with "spring" (the beginning of July) time of larvae feeding, e.g. the leaf beetle *Phytodecta pallidus* L., the moths *Oporinia autumnata* Bkh. and *Epinotia crutiana* L. Species with "summer" larvae feeding time possess low or fluctuating population density. Their population dynamics depends mainly on temperature conditions of growing season, while trophic factors is believed to be of higher importance for "spring" species.

### R6.3. POPULATION ECOLOGY OF MICROARTHROPODS IN RELATION TO

#### 7 VEGETATION AND RAINFALL

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For evaluating the combined effect of vegetation and rainfall on the seasonal distribution and relative abundance of microarthropods, a two year ecological survey was conducted in a bambooland and a grassland in Kerala. The influence of rainfall on the overall set up of soil population when analysed indicated that the population build up was largely influenced by Acari. The graphical representation of the data obtained from the bambooland and grassland on comparison showed three peaks, each for Acari and Collembola in the former site and a single peak in the latter one. Though the population of Acari always exceeded that of Collembola in the bambooland, the grassland showed an inverse relation between these two groups. The low density noted in the other microarthropod group may reflect its insignificant role in the total population structure. Although the rainfall received by the two sites was the same, the total content of soil population was comparatively greater in the bambooland, mainly contributed by few species of oribatid mites. The pronounced difference in the carrying capacity of the bambooland can be attributed to the coverage and high accumulation of organic litter capable of retaining moisture for longer duration in contrast to the open and litterless nature of the grassland.



**R6.3.** THE POPULATION-ECOLOGICAL EXAMINATION OF BUTTERFLIES  
**8** BY THE HELP OF CR-METHOD IN NATURE CONSERVATION AREAS

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Our examinations have been carried out on diurnal butterflies mainly in the territory of the Bükk National Park. The examinations primarily concerned the movement of species within the biotope or between biotopes, as well as dispersions within a habitat, the so-called spot to spot movement with special regard to the biotope proper and congeners. We were further interested in the relationship of these species with others and also started complex examinations concerning the dispersion of relating species, population dynamics and conditions of movement /*P. napi* - *P. bryoniae* species pair/.

It was established that the CR method is suitable to determine the conditions of movement, the dispersion in a given area, and the parameters of specimen number and population. Depending on the way of capture and intensity of sampling it is suitable for characterizing the population dynamics of a species. In this respect our studies should only be considered as preliminary. The final goal of our examinations is, from the point of view of nature conservation, to establish the size of the optimal or minimal area inhabited by the populations of the given species.

**R6.3.** INTRASPECIFIC LARVAL COMPETITION IN AGROMYZA FRONTELLA (DIPTERA:  
**9** AGROMYZIDAE).

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In laboratory studies, similar aged *A. frontella* larvae were found to be resource limited when developing in small leaflets and/or with other larvae. Larval mortality due to interference (cannibalism) during the first two larval instars, and exploitation (starvation) competition during the third and final instar, increased in a density dependant manner. Prepupal and pupal mortality increased and pupal weight decreased as larval density increased. However pupal developmental rates and adult sex ratios of survivors were not affected by larval density. Interference competition during the first two larval instars reduced larval density and thus diminished the probability that third instar larvae would be subjected to exploitation competition. These findings were confirmed under field conditions. Pupal weights and incidence of survival of individuals from the first laid eggs were significantly higher than those from individuals from eggs laid later, when the time between each oviposition was 24 or 48 h. Thus the persistence of *A. frontella*'s oviposition deterring pheromone (ODP) for periods > 24 h would confer a selective advantage to the progeny of ODP marking females.

**R6.3.** EFFECT OF INTRASPECIFIC COMPETITION BETWEEN LARVE OF  
**10** CALLIPHORA ERYTHROCEPHALA (MEIG.).

DR. A . SHAHEIN, Dept. of Entomology, Faculty of Agriculture  
University of Zagazig , Zagazig , Egypt .

Competition for food among larval population of C.  
erythrocephala (Meig) constitutes an important factor limiting  
the general fly population in nature. This factor is true ,  
since the primary factor which limits the abundance of any  
population of insects is the quantity of food which is  
available to it within its universe.

Investigations about the influence of intraspecific competition  
during the larval growth of this species were carried out  
to assess the following criteria : average dry weight of  
pupae, rate of pupation, rate of mortality among the larvae,  
rate of emergence and sex ratio .

6

**R6.3.** EFFECT OF PROTECTION ON THE FAUNAL POPULATION OF ASPHODELUS  
**11** MICROCARPUS, A COMMON PLANT IN THE EGYPTIAN WESTERN DESERT

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Agricultural Research Station, Alexandria, Egypt. "

An experiment of 8 successive years was carried out to study the  
effect of protection on the standing-crop biomass of Asphodelus  
microcarpus and its faunal population. Two grazing pressures were  
available, zero within the enclosure, and maximum obtainable out-  
side the fence. The results could be summarized as follows: a) The  
plant grew well and became dominant and the protected area appea-  
red more dense and darker in contrast to the surrounding grazed  
area. b) More destructive species were added to the faunal plant  
list and several insect outbreaks were recorded. c) After 6 years  
of protection the effect of insect damage inside the fence became  
worse than the effect of browsing outside. The protected area acted  
as a destruvtive faunal reservoir for the neighboring fig farms.  
d.) Protection had not pronounced effect on insects that attack  
plant parts which are out of hands of grazing animals.

**R6.3.** A NEW METHOD FOR CALCULATING THE DEVELOPMENT RATE OF THE IN  
**12** SECTS: THE "LOGISTIC REGRESSION".

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The Authors test out the three classical methods employed to study the influence of temperature on the development of the insects ("thermal summation", linear regression and logistic equation). After showing that, as regard the biological point of view, the logistic curve performs phenomena in the best way, the Authors remark that by this method it is not possible to estimate the level of the errors which can be made. For this reason they have thought to study a new method, called "logistic regression", which offers the advantages of both the linear regression and of the Davidson's equation.

**R6.4.** EFFECTS OF INTERACTIONS BETWEEN SYNOPTIC AND MESOSCALE WEATHER ON THE  
**1** MIGRATION OF INSECTS IN A CONTINENTAL CLIMATE

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Samples of insects and measurements of weather parameters have been obtained from the surface boundary layer and upper air (200-400 m) at sites in south-east Australia. At any one site there is a progressive rotation of winds due to the regular eastward displacement of weather systems. This rotation is accompanied by changes in the intensity of thermal convection (by day) and temperature inversion and wind shear (at night): maximum intensities occur in the northerly airflows preceding the passage of cold fronts while minima occur in the southerly flows in the wake of the front. A continuity between the cessation of thermal convection and the development of the temperature inversion before sunset ensures that conditions remain favourable for the continued migration of insects into the night. Migration rates are consequently greatest on the northerly airflows by day and night, and although such flows are short-lived they exert a major influence on the redistribution of insect populations in south-east Australia.

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Insect inputs into the marine environment were assessed in the area of the continental shelf off of the Southeastern Coast of the United States, in August and October 1983. Sticky traps, mercury-vapor lamps, and aerial insect nets equipped with flowmeters were deployed on oceanographic research vessels to estimate rates of insect deposition, nocturnal insect populations, and aerial insect density and species composition. Strong onshore wind conditions during this season were not favorable for insect biomass accretion. However, during intervals of calm weather, an unusual taxis is shown by various lepidopterons. These insects land in algal accumulations, which form in convergence zones. Lepidoptera was also the taxon predominating at light, with smaller numbers of Hemiptera, Odonata and Diptera recorded. Prevailing wind direction influenced aerial insect density, which at 20m elevation was generally less than one insect per  $6 \times 10^4 \text{ m}^3$ . The median length for all members of the 8 orders collected by all methods was 6mm (n = 218), however small insects (<3mm) are exceptionally prone to passive dispersal.

R6.4. DISPERSAL AND SPECIATION: TWO ASPECTS OF COLONISATION OF NEW ENVIRONMENTS  
3 BY THE AUSTRALIAN MOTH GENUS *PTEROLOCERA* (LEPIDOPTERA: ANTHELIDAE)

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The family Anthelidae is a conspicuous element of the Australian endemic moth fauna, with 90 species in 8 genera presently recognised.

The genus *Pterolocera*, with 27 species, is widely distributed, with its greatest development in southern Australia, where 22 species occur. In only one species are both sexes winged, the other 26 species have micropterous females and fully winged males. Dispersal of these latter species depends on high larval population densities. Under such conditions larvae become highly mobile, often moving long distances before pupation.

Populations of most species of *Pterolocera* are comprised of multiples of small semi-isolated demes, distributed as *chains* or *networks* which resemble the theoretical "stepping-stone" population models first proposed by Motoo Kimura in 1953. These characteristics make the genus of special significance in the study of population structure, speciation mechanisms, and evolutionary processes. Recent studies on several species of *Pterolocera* indicate that this genus has a specialised strategy for colonisation of new environments which depends on rapid adaptation and isolation of demes, resulting in rapid speciation.

R6.4.  
4

DISPERSION DYNAMICS OF DESERT BEETLES OF THE GENUS  
ONYMACRIS ( COL.: TENEBRIONIDAE, ADESMIINI) IN THE NAMIB

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The flightless *Onymacris* species - *O. plana*, *O. rugatipennis* and *O. laeviceps* - which all are active during day and dawn, occur annually in high density during the hot season ( January to March ) in the Central Namib in the area of the Kuiseb Wadi. Experiments with translocated beetles show that each species has a favoured habitat. In extensive field experiments with marked adults performed in 1968 to 1982, the used space of these beetles has been analysed and compared in view of their biology . The distance covered on feet by *O. plana* - which is provided with " sand shoes " - is unsurpassed. The biological significance of this migration behaviour is being discussed.

R6.4.  
5

AN INTERFIELD MOVEMENT MODEL OF A HERBIVOROUS INSECT WITH LIMITED  
FLIGHT ABILITY.

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Agricultural insect pests are often limited to specific field crops as a food source, and such unstable habitats necessitate movement for survival of the insect. In this model a system of distinct fields is considered, between which an insect of limited flight may move. It is assumed that these fields are points on a plane surrounded by circular regions of attractivity. The insect is assumed to move into a field, if it enters one of these circular regions. A computer algorithm uses this framework to simulate the interfield movement of an insect in a small farm system consisting of 100 fields or less. Varietal and phenological differences between fields may be incorporated.

R6.4. ABILITY OF EUROPEAN CORN BORER MOTHS TO MOVE BETWEEN "RENDEZ-VOUS"  
6 PLANT AND HOST PLANT ACCORDING TO INSECT SEX AND CROPS.

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This study was done in prospect to control the European Corn Borer by the mating disruption method. As far as we know, the possible movements of moths especially of the inseminated females from "refuge plant" to the maize have not been studied well. The author simultaneously uses two technics : visual observation and light trapping of wild insects and coloured moths previously released. It is established that the females, since emergence, are attracted by the host plant (maize). On the contrary, the males do not present such a behaviour : they stay on place or fly independently of the crop.

An hypothesis to explain that behaviour difference is given and the use of mating disruption method to control this pest is discussed.

R6.4. LARVAL DISPERSAL OF THE SPOTTED STALKBORER CHILO PARTELLUS (SWINHOE)  
7 (LEPIDOPTERA:PYRALIDAE).

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Larval dispersal through spinning off on silk threads is a wellknown phenomenon especially encountered in lepidopterous forest pests.

In recent years fieldwork from India and Africa has shown that the first instar larvae of Chilo partellus - an important pest on graminaceous hostplants - also disperse on silk threads and that this dispersal might well be an important factor for spreading the infestation in the field.

By using a windtunnel the behaviour of newly hatched larvae of Chilo partellus originated from Southern Mozambique is being studied under laboratory conditions. In the ongoing experiments the larval dispersal is being observed particularly in relation to various plant quality factors such as different age and varieties of maize and sorghum.

**R6.4.**  
**8** THE CORRELATION OF PHASE VARIATION IN THE COTTON LEAFWORM, ALABAMA  
ARGILLACEAE, WITH ITS PREMIGRATORY CONDITION.

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Cotton leafworm larvae exhibit a density-dependent color phase variation, which was correlated with the adult reproductive-flight syndrome. Characteristic behavioral and physiological differences separate premigrant from nonmigrant individuals. Cotton leafworms were initially classified as premigrants and nonmigrants based on mating status, ovarian development, oviposition, and hypertrophied fat body. Flight initiation by black-phase-variants during the passage of cool weather fronts was a good indicator of migratory status. Cold front passage appears to inhibit flight of non-migratory green-phase-variants.

**R6.4.**  
**9** MOVEMENT AND REPRODUCTION OF THE BEAN BUG, RIPTORTUS  
CLAVATUS THUNBERG IN SPATIO-TEMPORALLY HETEROGENEOUS HABITAT.

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Many insects lay their eggs in places where the offspring are expected to survive. The habitat seems to be especially important for insects living in heterogeneous habitats and using temporary resources such as plant seeds as food. Movement and reproduction of the bean bug, Riptortus clavatus were investigated from this viewpoint with mark and recapture method. R. clavatus feeds on seed of leguminous crop and has a long reproductive period. There were four kinds of host plants in the field investigated, i.e. soybean(Glycine Max), pea(Pisum satium), kidney bean(Phaseolus vulgaris), and string bean(Phaseolus vulgaris), and about fifty patches of them were scattered in the field. Larval survival rate was highest on soybean and lowest on string bean. Pre-reproductive females stayed 5.6 days in a soybean patch and 2.2 days in a string bean one on average. In contrast, reproductive females stayed only 1.7 days in a soybean and less in a string bean patch. Reproductive females moved longer distances than pre-reproductive ones. Season and the age of host plant also influenced the movement of R. clavatus. The adaptive significance of these changes in movement pattern is discussed.

**R6.4.** STUDIES ON THE MIGRATION OF THE WHITE BACK  
**10** PLANTHOPPERS (*SOGATELLA FURCIFERA* (HORVATH) )

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Studies of the migration of the white back planthoppers showed that in warm-winter years the north limit of overwintering was about 26°N. The population of south China in the early spring came continuously from the Indo-China Peninsula from March to June, carried by the south-western atmospheric current. After one or two generations in the southern paddy field, the population gradually migrated northward with the south-western or south-eastern airflow. After mid and late August the northward migration is prevented by a cold atmospheric pressure. The white back planthoppers in the northern paddy field migrated back southward along the north-eastern atmospheric current. The regions infested by the white back planthoppers are divided into 5 belts and 16 subbelts as forecasting bases according to the time of damage to the rice and other factors.

**R6.4.** SYUDIED ON THE PHYSIOLOGICAL AND ECOLOGICAL CHARACTERS OF THE FLIGHT  
**11** AND MIGRATION OF RICE LEAF ROLLER (*CNAPHALOCROCIS MEDINALIS* GUENÉE)

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Department of Plant Protection, Nanjing Agricultural College, Nanjing,  
People's Republic of China

The cold hardiness, northern boundary of overwintering, the seasonal reproductive diapause as well as the northern and southern migration routes of the rice leaf roller *Cnaphalocrocis medinalis* had been studied by us previously. Experiments were conducted to study the ecological signals and the physiological characters of the migration. Short photoperiods (<13.5hr) and high temperatures (>28°C) are found to be the two key factors in inducing reproductive diapause and emigrations and they also restrict each other. The different critical photoperiods and temperatures for emigrations in various regions were studied. Physiologically, there are obvious difference in crude fat contents among adults sampled from various types of population sources. Fat contents of the emigratory-type is higher than the local-type, and the immigratory-type is the lowest one. Tether flight test indicated that the continuous flight of the moth not only consume much of fat contents, but also promote the development of the ovaries. When juvenile hormone (ZR-619) was topically applied to the meso-notum of late pupa under the unfavorable high temperatures, it was found that the dosages over 0.01µg each pupa promote the development of ovaries beyond about one growth stage at 70 hrs after emergence. However, topically treatment with anti-JH (precocene-II) under the favorable temperature conditions with the dosages over 1µg each pupa delay the ovarian development for 0.6-0.8 growth stage at 66 hrs after emergence, and the mature ootids decrease about 81.6 %.



**R6.5.****1****HOST AND DIAPAUSE STRATEGIES IN DIPRIONID SAWFLIES.**

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Diprionid sawflies are a well-defined group of Hymenoptera who thrive in the northern hemisphere. The larvae of most species feed on Pinus, but a few species have colonised the more protected hosts Picea and Abies. Winter is spent as an egg in the leaves or as a larva in its cocoon. Egg diapause is intrinsic and results in univoltinism throughout the range of a species like Neodiprion pratti. N. lecontei, a wide spread species with a larval diapause, has a single generation in Ontario and up to four generations in Florida. The critical photoperiod for diapause induction increases from a mere 12 hours in the south to around 16 hours in the north. Diapause intensity and duration increase from south to north, where the termination requires a lengthy cold treatment not needed in more favoured climates. Photoperiod response, diapause intensity and duration are controlled by only a few alleles. High intensity diapause traits of northern populations are dominated by the low intensity traits of southern populations when the two strains are hybridised, i.e. are Mendelian recessives.

**R6.5.****2****ENVIRONMENTAL CUES IN LIFE-CYCLE STRATEGIES AND  
DIAPAUSE OF COCCINELLIDAE**

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Photoperiod, temperature and food play important roles in the regulation of life-cycles in *Coccinella septempunctata*, *Semiadalia undecimnotata* and *Coleomegilla maculata*. Most surprising seem the divergent strategies in using photoperiodic cues in two subspecies of *C. septempunctata*. While long-day response was ascertained in all populations from Europe and central Asia, *C. s. brucki* from central Honshu, Japan, was found to be a short-day insect. The important ecological plasticity of *C. septempunctata* is to a great extent due to the photoperiodic polymorphism of most populations.

**R6.5.** LIFE HISTORY STUDIES IN THE GENUS *YPONOMEUTA* : THE DIAPAUSE OF  
**3** *Y. VIGINTIPUNCTATUS* ( LEPIDOPTERA; YPONOMEUTIDAE ).

G.J. KUSTERS

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Among eight species of *Yponomeuta* four different types of diapause are known, whereas three of the species, feeding sympatrically on one and the same host-plant species, hibernate in three different ways. Seven of the species are univoltine, one is multivoltine. These facts make the members of this genus very suitable for a comparison of life cycle strategies and in particular in the context of the broad approach aimed at the reconstruction of the phylogeny of the genus.

The study is concentrated at the moment on *Y. vigintipunctatus*, since its facultative, pupal diapause, easily manipulated by photoperiod and temperature, enables us to look at this primary life history parameter in greater detail. Information is given on various, sometimes interrelated, developmental and diapause traits, and for some of these traits the sex-linked inheritance is discussed, as obtained by crossing and backcrossing experiments.

Different levels of variation are chosen: the inter- and intrapopulation level, using several populations from Europe, and the inter- and intra-individual level, making use of isofemale line data.

6

**R6.5.** PROLONGED DIAPAUSE IN YUCCA MOTHS  
**4**

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University of California, Berkeley, CA USA

Prolonged diapause, an arrested state of development for more than 1 yr, appears to be especially important to insects that are dependent upon particular seasonally-limited organisms. In North America, 3 genera of moths (Incurvariidae: Prodoxinae) depend upon the brief flowering of *Yucca* (Liliaceae).

The legless larvae of *Prodoxus* feed in sterile tissue of *Yucca* inflorescences and prepupal larvae overwinter there; 4 species on *Y. whipplei* and *Y. schottii* in California and Arizona were intensively studied. Their larvae may remain in diapause 4-8 yrs, even though neighbors in the same plant complete development in a prior year. Autumn and midwinter samples were subjected to reciprocal tests in artificial environments, with manipulated temperature, direct moisture, and light. The results show that the diapause-ending process is complex, requiring gradually lowering temperature in late winter, coupled with moisture factors, for optimum response; there is considerable intra- and interpopulational variation in response. Elimination of light from Nov. to May had no effect on diapause termination, compared to samples held in subdued natural light.

Diapause of an entire population of *P. aenescens* may precede emergence up to 6 yrs, but mortality increased significantly as compared to yr 4. Field evidence from several species indicates that prolonged diapause commonly occurs in natural populations. The data demonstrate that there is no strict genetic polymorphism in which a certain percent of individuals carryover, irrespective of environmental cues. Rather, it appears a spectrum in genotype underlies variability in response to conditions that maintain and terminate diapause.

**R6.5.** TIME OF DIAPAUSE TERMINATION IN EUPHYLLURA SP. ON OLIVES,  
**5** IN NORTHERN GREECE

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The species of Euphyllura (Homoptera: Psyllidae) which infests olives in N. Greece has an aestivo-automno-hibernal diapause. Adults collected in the grove every two weeks from September through February, were transferred to 12 h and 19°C for their diapause condition to be assessed. The stage of ovarian development, 2 and 4 weeks later, showed that diapause in the field was terminated approximately at the end of December, i.e. long before the end of the cold season.

**R6.5.** DIAPAUSE TERMINATION IN EURYTOMA AMYGDALI UNDER VARIOUS  
**6** PHOTOPERIODS AND TEMPERATURES

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Mummified almonds containing diapausing larvae of E. amygdali Enderlein (Hymenoptera, Eurytomidae) were collected on various dates and subjected to various controlled conditions, then to 16 h and 19°C. Adult emergence dates showed that: 1) In nature, diapause was terminated in mid winter. 2) The requirements for diapause termination differed with the stage of diapause development. In those larvae collected in mid September, 16 weeks of short photophase with chilling were favorable; in those collected in late November, 8 weeks of short photophase without chilling were sufficient although the addition of chilling gave an earlier and more homogeneous termination of diapause; in those larvae collected in late December, diapause was terminated under a short or a long photophase, without chilling.

**R6.5.** HETEROGENEOUS LIFE HISTORY IN THE SPIDER MITE (*SCHIZOTETRANYCHUS*  
**7** *SCHIZOPUS* (ZACHER))

GOTOH, T. Institute of Applied Zoology, Faculty of Agriculture, Hokkaido  
University, Sapporo, 060, Japan

The spider mite, which occurs on the willow (*Salix subfragilis* Anders.), passes four generations in Sapporo and overwinters as an egg. In this species, the diapausing eggs frequently appear on the willow branch in the summer time (early or mid July), though in most species of spider mites, diapause is uniformly induced in autumn. This is because some of the individuals in the second generation females oviposit diapausing eggs. The proportion of diapause-egg laying females in a population increases with the progress of generations.

Fifty percent diapause is induced in the field in late July or mid August, which is earlier by ten or thirty days than the time expected for the critical photoperiod (14 hr at 18°C). In short, diapause is induced at a long photoperiod (15 hr or more) and high temperature (23°C) conditions. Thus the emergence of diapause-egg laying females in the second generation may be controlled by factors other than photoperiod and temperature. One of the possible factors appears to be deterioration of leaf nutrition, because willow leaves fall down irregularly and bronzing of leaves, which is unfavorable for mite development, prevails in mid August. Therefore, I considered that the heterogeneous life history of this species may be related to an adaptation in which individuals in the population show different timings of oviposition from year to year corresponding to changing nutritional conditions of leaves.

**R6.5.** THE CIRCADIAN ACTIVITY RHYTHMS OF CARABID BEETLES FROM DIFFERENT  
**8** GEOGRAPHIC LATITUDES

GISELA LEYK

Zoologisches Institut, III. Lehrstuhl, Weyertal 119, D-5000 Köln 41

Comparative studies of the circadian activity rhythms were performed with three stocks of the species *Pterostichus rhaeticus* Heer (from southern Europe, Central Europe, and the Subarctic) and with one Central European stock of the sibling species *P. nigrita* Paykull. The behaviour was investigated under various LD-cycles (with T=24 h and differing periods), constant conditions, DD with light pulses, and temperature cycles with constant illumination. The analysis of the data - including various methods of time series analysis - revealed considerable differences between the populations from different latitudes. Characteristic alterations concerning behaviour in south-to-north direction have been observed.(e.g. in the tendency to rhythmic behaviour, lability of the rhythms, variability of behaviour). The results, especially those from pulse experiments (e.g. fundamental alterations of behaviour) and LL with changing illumination (e.g. splitting in three components with different periods), support a multi-oscillator-model.

**R6.5.** ADAPTATION OF ORIGINAL INSECT POPULATION TO LABORATORY  
**9** REARING

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Time periods of insect survival and adaptation are established. Original number of insects required for long-term maintenance of the laboratory culture is determined.

**R6.5.** INSECT LIFE IN THE SNOW AND ICE OF THE HIMALAYAN GLACIER  
**10**

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A cold tolerant insect which lives only in the snow and ice was discovered from a high altitude glacier of Nepal Himalaya. This is a new species of Chironomidae (Diamesa Meigen sp.) characterized by reduced wings and antennae. They cannot fly and only walk on the surface of the glacier and in the small cavities in the snow and ice. Larvae grow in the under-snow melt water drainage on the glacier ice by eating micro plants: blue-green algae and bacteria. Adult females make a sun-compass oriented upstream migration by walking on the snow surface, probably to keep their distribution area on the glacier against downstream flow of their eggs and larvae.

**R6.5.** ALPINE INSECTS OF URALS.  
**11**

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During the investigations of insect population of the Ural mountains alpine tundra the similarity and originality of this complex of animals vs. those of tundra zone were established. Urals alpine insects fauna included Holarctic, Arcto-alpine and Transpalaearctics species. Most of arcto-alpine species are Holo-coen relicts, such as coccid *Arctorthesia cataphracta* Sahlb. (Ortheziidae, Homoptera). Total biomass of insects averages to 0,2-0,5 g/m<sup>2</sup> in the Polar Urals, to 1-2 g/m<sup>2</sup> in the North Urals and increases to 6 g/m<sup>2</sup> on tundra plots of the South Urals ( in fresh weight). Alpine tundra plots of all regions of Urals have similar number of dominant species of insects. There are about 10-15 dominant species , their abundance are more than 1 ind/m<sup>2</sup>. They are the objects of close ecology but different taxonomy.

6

**R6.6.** ECOLOGICAL IMPLICATIONS OF LIFE CYCLE VARIATION IN APHIDS  
**1**

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Aphids have elaborated the mechanism of cyclical parthenogenesis to a high level of complexity, with an ecological differentiation between the bisexual and the parthenogenetic phases. However, wholly parthenogenetic clones are also well known for many aphid species. Holocyclic and anholocyclic clones of the polyphagous aphid *Myzus persicae* (Sulz.) coexist for example in the Rhine Valley. A comparison of more than 600 holocyclic clones with more than 300 anholocyclic clones of this species from the Rhine Valley shows a wide genetic variability in population increase on sugar beets and potatoes and in insecticide resistance. However, holocyclic and anholocyclic clones have in average a different adaptation to these traits. The results will be discussed with special reference to the ecological genetics of life cycle variation in aphids.

**R6.6.** Interactions of Greenbug and Drought Stresses with Various Winter  
**2** Wheat Genotypes

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Laboratory, greenhouse, and field studies were utilized to discern how greenbug and drought stresses interact to cause damage in winter wheat. Wheat varieties were chosen to represent the range of plant responses to these stresses, including both resistant and susceptible genotypes. Findings to be discussed include: how greenbugs and drought-stress affect various plant factors such as membrane stability, free amino acid content, and yield components; how drought-stress interacts with wheat genotype to influence greenbug biology.

**R6.6.** LIFE HISTORY OF A MONOPHAGOUS FRUIT-BUG, PARASTRACHIA JAPONENSIS  
**3** (CYDNIDAE: SEHIRINAE)

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P. japonensis is distributed in southern Japan and China. It is monophagous, feeding only on the drupe of Schoepfia jasminodora tree (Olacaceae). Its distribution and habitat, and its life history, closely parallel those of Schoepfia. Adults of P. japonensis form large aggregations (sometimes, some thousands) on the short trees under the dark laurel forest. Most adults in the aggregation appear to be in diapause, neither moving nor feeding. When Schoepfia trees bear drupes, some females leave the aggregation. They feed on the drupes, and deposit a ball-shaped batch of 60 to 100 eggs. After oviposition the female sits on her egg batch. If disturbed, she transfers the egg batch with her rostrum. Nymphs feed on fallen drupes. But, because the quantity of drupes is limited, some cannibalism of nymphs occurs. The emerging adults join the adult aggregations of the former generation on the leaves.

**R6.6.** Investigation On The Biology of Acrotylus insubricus(Scop.) (Orth.-  
**4** in Karaj Vicinity And Under Laboratory Conditions. Acrididae)

AZMAYESH FARD PARVANEH

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Acrotylus insubricus (Scop.) has a vast distributional range in Iran. A. insubricus - insubricus (Scop.) is distributed in Northern, western and central provinces, but A. insubricus inficitus (Walk) is recorded from central provinces. This insect is polyphagous and prefers noncultivated, arid areas around the farms and ranges, they migrate from areas bringing under irrigated cultivation and cynodon dactylon is one of the most preferred host plant. A. insubricus can be reared in laboratory, under 28-35 °C, 30-50 percent R.H., 9 hours of light and fed by alfalfa and cynodon dactylon.

Laboratory investigations show that the mean incubation periods are 18, 15.3, 15.2, 14 & 11 days under 27, 30, 33, 36 & 40 degree centigrades respectively. The mean nymphal duration was 9.5, 10.5, 11.8, 12 & 12.2 for first, second, third, fourth and fifth instar respectively. The mean total length of nymphal period was 56 days. The mean adult male longevity about 35 and the female about 28 days.

**R6.6.** SEASONAL VARIATION OF ARTHROPOD FAUNA AND SPILARCTIA  
**5** CASIGNATA KOLLER IN SOYBEAN ECOSYSTEM.

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A survey of arthropod fauna, in 3 varieties of soybean (Sathia, Ransum and Hill), was conducted to see seasonal variation of economically important arthropod including Spilarctia casignata which is a major pest of soybean in this region. A whole plant (10 samples/plot/2 weeks) and a pitfall (5 traps/plot/week) sampling methods were used from June to September, 1983. Of 46 species in 34 families, 28 insect species, 8 spider families and 3 non-insect arthropods, have been identified. Major activities were seen in July. This complex of arthropods was composed of sheltering, soybean feeding, weed feeding and natural enemies of all the above. Pitfall trap was useful for 15 species of crawlers, mostly sheltering.

First batch of eggs of S. casignata was observed on June 10th. Although 5 colonies (180-315 eggs/colony) were observed at different times, only 5 larvae were caught in the samples from var. Sathia and Ransum but none from Hill. Field cage study showed that the life cycle required about 6 weeks ( $\bar{X}=38 \pm 2$  days;  $N=5$ ). This moth had 3 generations/yr according to the distribution of egg colonies during the sampling period.



**R6.6.** ENVIRONMENTAL MANIPULATIONS AS AFFECTING POPULATIONS OF THE  
**6** SUGARCANE BORER

T. E. REAGAN

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Cultural practices enhancing arthropod predation on the key sugarcane pest, Diatraea saccharalis(F.), include crop ratooning and the encouragement of minor weed infestations (sub economic threshold), particularly of annual grasses hosting alternate food for Solenopsis invicta BUREN and other predators. Though 3-fold differences in susceptibility exist among commercially grown varieties in La., the moderately resistant CP65-357 has provided substantially the greatest pest reductions.

Recent increases in D. saccharalis occurred largely from new highly susceptible varieties and production of alternate host crops. Three times the production of D. saccharalis pupae and adults/ha of sugarcane is produced in sweet sorghum through the manipulation of planting and harvesting schedules for energy alcohol.

**R6.6.** DEVELOPMENT OF THE CAROB MOTH AS AFFECTED BY HOST PLANT  
**7** TISSUES AND APANTELES PARASITE .

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Carob moth Ectomyelois ceratoniae Zell., is the most important pest on pomegranates in Iraq. Females laid eggs singly in the calyx tube. Newly hatched larvae fed inside during the first and second instar, they were either completely developed inside the calyx or tunnelled into the pericarp .

The parasite female Apanteles ultor sp. group deposited single egg in the first or second instar host larva . The behavior of the parasite on its host was studied. The host parasite relationship with the host plant were investigated by rearing the host larvae on artificial diet containing one of the following fruit tissues: calyx, stamens , stigma, and pericarp.

The type of tissue significantly affected larval development time , pupal weight , and larval mortality . Larvae preferred stamens and calyx tissues to pericarp and stigma .

R6.6.  
8

## RESISTANCE OF COTTON TO SPIDER MITES INDUCED BY PREVIOUS HERBIVORY

RICHARD KARBAN

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Mite populations grew more rapidly on new growth of cotton seedlings that had never been exposed to mites than on new growth of plants whose cotyledons had been previously exposed to them. Reduced population growth was also induced by a second mite species and by mechanical abrasion of the cotyledons. The response was density-dependent; the larger the initial exposure to mites, the smaller was the subsequent population buildup.

6

## R6.6. THE BIOLOGY OF THE TWOSPOTTED SPIDER MITE, TETRANYCHUS 9 URTICAE AS AFFECTED BY RESISTANT SOLANACEOUS PLANTS

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Two solanaceous plants, Lycopersicon hirsutum F. glabratum Humb. & Bonpl. and Solanum sarachoides Sendtner were found to be resistant to the two spotted spider mite, Tetranychus urticae Koch. Leaves of both host plants are covered with glandular hairs and mites were quickly entrapped in their exudate. Even when stripped of glandular hair exudate, leaves of these plants were found improper still for mite development. On L. hirsutum leaves stripped of exudate, 40% of T. urticae larvae developed to the deutonymphal stage, but none survived till the adult stage. On similar leaves of S. sarachoides, all mites died before reaching the deutonymphal stage.

For comparative purposes, the experimental work included also leaves of L. esculentum, c.v. Stakeless upon which 40% of the larvae reached the adult stage.

**R6.6.** REARING THE CORN BORER *SESAMIA NONAGRIOIDES* ON ARTIFICIAL MEDIA IN  
10 THE LAB.

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Attikis, Athens, Greece.

In the last few years the corn borer, *Sesamia nonagrioides* (Lef.), has become a major pest in the late corn crop. To develop a method for the control of the insect, the study of its biology, ecology, and artificial rearing has started. A larval diet that has been developed includes the following ingredients: water, brewer's yeast, wheat germ, corn cob, sojal 8 (a mixture of hydrolyzed soy, wheat flour, and a salt mix), VanderZant vitamin mix, ascorbic acid, nipagin, potassium sorbate and hydrochloric acid.

At 25°C larval survival was 68%, mean larval developmental period 30 days, pupal developmental period 11.5 days, mean pupal weight 143 mg, adult emergence 88.5%, and the sex ratio ( $\sigma:\varphi$ ) 1:1.06. Mean adult survival was 3.9 ( $\sigma$ ) and 4.3 ( $\varphi$ ) days, mean egg production 309 eggs/female, and hatchability 84%.

The insect has been reared on the diet for three consecutive generations. Further studies on the physical and nutritional properties of the diet will lead to its optimization.

**R6.6.** THE INFLUENCE OF INTENSIFICATION OF THE GARDENING OF THE  
11 SUCCESSION PROCESSES ON ITS ENTOMOCENOSES

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Transition to industrial gardening in the Georgian SSR, the wide use of pesticides provoked acceleration of the succession processes. The dominant species are defoliator pests (Lepidoptera) before and during the use of inorganic pesticides. The subsequent change of the dominant species takes place after the application of chlororganic and organophosphorous pesticides: Palaeolecanium bituberculatum Targ.(Coc.) and Synanthedon myopaeformis Bkh.(Lep.) replaced by Stigmella malella Stt., which are forced out by Tetranychus viennensis Zacher.(Tet.) and Panonychus ulmi Koch.(Tet.). Consequently, the ousting of monovoltine species by polyvoltine, polyphagous and wide oligophagous and monophagous insects. A tendency to a decrease of line dimension of the dominant species has been observed.

R6.6. TEMPORAL DISTRIBUTION OF OVIPOSITIONAL POTENTIAL  
12 IN CERTAIN PHYTOPHAGOUS SCARABS

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The study of differences in the reproductive strategies of closely related species may yield information that is helpful to the understanding of their relative abundance. Reproductive flights of phytophagous scarab beetles occur in a characteristic sequence from spring through late summer in North Central Texas. These flights were sampled daily throughout the springs and summers of 1979, 1980, and 1981 by means of a black-light trap. A subsample of the females of each species were removed from each day's catch and dissected to determine the number of mature-sized eggs in their ovaries. Less than 50 percent of the females of some species contained mature eggs; among the primary pest species, however, that figure was nearly 100 percent. The number of mature eggs per female (excluding females with no mature eggs) also tended to be relatively high in important pest species, although some less abundant species had as many or more mature eggs per female. The females of one moderately abundant species were exceptional in that they lacked mature eggs early in their flight season. The primary pest species exhibited no sign of such a period of reproductive unreadiness. Immature eggs were present in all females examined.

R6.7. FOOD AND HABITAT SELECTION OF SCARABAEID DUNG BEETLES  
1

S. ENDRÖDY-YOUNGA

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Food and habitat selection of scarabaeid dung beetles were tested in wooded savanna conditions at Nylsvlei in the northern Transvaal, South Africa. Food preferences of 74 species were recorded on cattle dung (large herbivore), human faeces (omnivore), rotten meat, and fermented fruit. For habitat selection open grassland, a turf vlei, and two wooded savanna sites were compared. An unexpectedly great difference in the composition of catches was recorded between the two wooded savanna sites, which differed from one another only in the amount of shade provided by bushes and trees.

R6.7.  
2

FLIGHT ACTIVITY, FORAGING BEHAVIOUR, AND COMMUNITY  
STRUCTURE AMONG NEOTROPICAL SCARABAEINAE.

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Passive flight interception and baited pitfall traps were used to sample Scarabaeinae from several forest locations in Panama and Costa Rica. Hourly flight data were compared with overall activity and the ability to locate and utilize food resources. Tropical forest scarabaeines exhibit a variety of perching and flying strategies to detect potential resources. The varied nature of such foods (dung, carrion, fruit, and detritus) in size, space, and time has allowed the evolution of equally diverse behavioural methods of utilization. The problems of using baited trap data are discussed with respect to questions on resource partitioning and competition.

R6.7.  
3

STRUCTURE OF A DUNG BEETLE COMMUNITY IN MEXICAN TROPICAL  
MOUNTAINS

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The structure and function of biological communities are affected, and in several instances determined, by the characteristics of species that constitute them and by interactions between them. Several factors regulate coexisting species number in a particular place and time. The structure of a Scarabaeinae (dung beetle) community in the tropical mountains of Mexico is studied using trophic and reproductive characters, which were analyzed by multivariate methods (cluster and ordination analysis). The results suggest that reproductive strategy, body size, bisexual cooperation, egg chamber structure, activity timetable and typical habitat are of importance to community structure. The most important separating characteristics for woodland species are spatial-temporal characters and for openfield species body weight and dimensions. Lastly species structure and composition in these tropical mountains are greatly influenced by biogeographic overlaps creating communities richer than expected and of diverse historical origins.

**R6.7.**  
**4** SEASONAL ABUNDANCE OF FIVE COMMON CARRION BEETLES,  
IN A PASTURE FIELD, SAN CRISTOBAL, VENEZUELA.

DANIELA HAVRANEK

U.N.E.T., Apartado 436, San Cristóbal, Edo. Táchira, Vzla.

A total of 917 beetles, 23.9% Canthon cyaneellus sallei Harold, 26.4% Coelodes castanea Westwood, 27.9% Phanaeus (Coprophanaeus) telamon telamon Erichson, 14.2% Oxelytrum cayennensis (Sturm) and 7.6% Xenocanthon sericans (Schmidt) were collected between Feb. 1982 and Oct. 1983 at a pasture field near San Cristóbal, using five fish baited pit-fall traps. Similar abundance patterns were observed during the two years, for the species considered. C. castanea had a sporadic seasonal abundance. Comparing O. cayennensis with X. sericans, both had a similar seasonal appearance at a low abundance level while C. c. sallei and P. t. telamon had a similar seasonal appearance but with a much higher abundance level. Statistical analysis indicated a strong correlation between the number of insects captured and the total monthly precipitation as for P. t. telamon, X. sericans and C. c. sallei.

**R6.7.**  
**5** WINTER SURVIVAL OF ONTHOPHAGUS BONASUS (FABRICIUS) AND ONTHOPHAGUS  
GAZELLA FABRICIUS IN THREE TEXTURAL CLASSES OF SOIL

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Winter survival of Onthophagus bonasus (F.) and Onthophagus gazella F. were studied in three different textural classes of soil during two winter seasons in south-central Texas. Both species made brood cells deeper in sandy soil than in clay loam soil but survival during the winter months was greater in the clay loam soil for both species. There was no survival of either species in areas with a water table 20 to 35 cm below the soil surface.

R6.7.  
6

Succession of coprophilous entomofauna in cow dropping

WOJCIK W.F. BEDNAREK A. NOWICKI T.

The Authors presented the results of their investigation in ecological succession of coprophilous entomofauna in cow dropping in particular of the Scarabaeidae and Sphaeridiidae families. The ecological experiment was performed. 54 portions of the fresh cow dropping /0,5 kg each/ have been put up on 3 posts. It was carried out on the part of pasture land near Warsaw. For 5 days, every 4 hours two portions of dung from each post were collected. All insects were taken out of the portions using the flotation method. The experiment was repeated 3 times: in June, August and September 1981.

R6.7.  
7

HOST PLANT RESISTANCE AND TOLERANCE, INSECTICIDES AND NATURAL CONTROL OF GRASS GRUB IN NEW ZEALAND PASTURES.

R. EAST

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The root-feeding larva of the grass grub, *Costelytra zealandica* (White) (Coleoptera: Scarabaeidae), is the most serious insect pest of New Zealand pastures. Grass grub populations increase following cultivation to reach severely damaging levels in ryegrass/white clover pastures. In the absence of insecticide treatment, populations subsequently collapse naturally to low levels. In at least some cases population collapses are caused by protozoan and bacterial pathogens. Use of insecticides to control grass grub leads to population resurgence, necessitating repeated insecticide applications. This problem can be overcome by basing control on resistant or tolerant legumes and grasses, such as lucerne, tall fescue and cocksfoot, which raise the damage threshold and do not interfere with the natural suppression of grass grub numbers.

**R6.7.** KLEPTOPARASITISM OF *APHODIUS COENOSUS* IN NESTS OF  
**8** *TYPHAEUS TYPHOEUS*, CONTRIBUTING TO THE GENESIS OF SOME  
SANDY SOILS.

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The Netherlands

It was established that *Aphodius coenosus* (Col., Aphodiidae) is a kleptoparasite in nests of *Typhaeus typhoeus* (Col, Geotrupidae). This is the first record of kleptoparasitism in *A. coenosus* and of a kleptoparasite in the nest of *T. typhoeus*.

In the laboratory, newly emerged *A. coenosus* adults moved to the surface while back-filling their burrows. Back-filled burrows (approx. 4 mm in diameter) were also found in the field, together with back-filled burrows from *T. typhoeus* (approx. 14 mm in diameter). Ancient back-filling traces of the *Typhaeus* type have been dated from the Late Weichselian/Early Preboreal (c. 10000 years before present). These traces are also accompanied by back-filling traces of the *Aphodius* type. The latter traces add to the evidence that the former traces originate from large, presumably geotrupid, dung beetles.

The behaviour of dung beetles and the resulting back-filling traces help to explain the genesis of some sandy soils in NW Europe.

**R6.8.** THE EFFECTS OF GEOTHERMAL ENERGY ACTIVITIES ON AQUATIC INSECTS  
**1**

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Benthic sampling programs, field manipulations, and laboratory experiments have been used from 1975 to the present to evaluate the effects of thermal and chemical components of geothermal fluids (which may result from accidental releases during geothermal energy development and operations) on aquatic insects of Big Sulphur Creek, a stream at The Geysers (northern California, USA), which is the world's largest geothermal energy development. Studies using in situ stream microcosms indicate that the thermal component of geothermal fluids has greater influence than the chemical component in determining aquatic insect community features. Populations that are tolerant of geothermally related activities include the caddisflies Gumaga nigricula and Helicopsyche borealis; their bionomics and tolerances to environmental perturbations are presented. A monitoring program that enables decisions to be made as to whether a priori defined changes in benthic community have occurred has been developed based on sequential analysis techniques. Results of the above studies suggest research approaches for determining underlying relationships between aquatic insects and environmental disturbance, and consequently avenues toward developing appropriate mitigation procedures.



**R6.8.** ECOLOGY OF INSECTS INHABITING TEMPORARY PONDS IN  
**2** THE UPPER RHINE VALLEY

BECKER, N. and LUDWIG, H.W.

(Inst. Zool., Univ. Heidelberg, F.R.G.)

The influence of abiotic parameters on the occurrence of various insect orders (Coleoptera, Diptera, Heteroptera and other groups) was investigated. Abiotic factors influencing the distribution of water inhabiting imagines or larvae are mainly periodicity of the water body, pH, temperature, carbon-dioxide and oxygen content. Besides the morphology of the ponds the amount of detritus of plant origin is decisive. Habitats investigated comprise snow melt ponds in swampy woodlands as well as temporary ponds in the flood-lands of the river Rhine. For each type of pond typical insects are specified.

**R6.8.** THE LIFE HISTORY STRATEGIES OF *SIMULIUM VITTATUM* ZETT.  
**3** (DIPTERA: SIMULIIDAE) IN THE RIVER LAXÁ, N-ICELAND

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Institute of Biology Department of Zoology

University of Iceland University of Newcastle upon Tyne

*Simulium vittatum* is the dominant species in the R. Laxá. It is a univoltine species. In the upper reaches of the river (close to the outlet) each generation was clearly divided into 2 cohorts. One cohort grew very rapidly over the summer, with a life span of about 2 months. The other cohort grew more slowly, with a life span of one year. In the lower reaches of the river, only the slow-growing cohort existed. The larvae fed on fine particulate organic matter (FPOM) drifting from the source of the river, Lake Mývatn. In 1978-82, a reduction of FPOM was 30%, and the relative proportion of fast-growing larvae in the summer population fell from ca. 30% (1977) to about 10% (1978-82) in the outlet and nearly disappeared 4 km below the outlet. The quantity of FPOM seems to affect the types of life cycles in the species, as well as the production.

**R6.8.**  
**4** EGG DEVELOPMENT OF EXOPTERYGOTE INSECTS IN FRESHWATER

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Many adaptations determine the occurrence and seasonal cycle of an insect species or population, and these include the timing of the periods of development, reproduction, dormancy, and migration in relation to seasonal changes in biotic and abiotic factors.

The egg stage is often the least understood of the major stages, but information on hatching time and other egg-stage phenomena is essential for the interpretation of life cycles.

Quantitative information is now available on the hatching of several European species of Ephemeroptera, Plecoptera and Odonata. Differences in the occurrence and life cycles of these freshwater insects can partly be explained by variations in hatching success and hatching times at different temperatures.

6

**R6.8.**  
**5** POPULATION VARIATIONS OF PHLEBOTOMID IN BIRBHUM,  
WEST BENGAL (INDIA)

SOMNATH BANERJEE  
DEPARTMENT OF ZOOLOGY, SURI VIDYASAGAR COLLEGE  
BIRBHUM (WEST BENGAL) INDIA.

Assessment of population of phlebotomid Sand flies is important in the control of Kala-azar. Bimonthly surveys were undertaken for one year from December 1980 to November 1981 to study numerical fluctuation of populations of Phlebotomus argentipes and Phlebotomus papatasi from Kala-azar affected district Birbhum. Sand flies were caught with an aspirator tube and flash light per manhour from five localities of Suri, Birbhum. The total number of phlebotomid fauna showed an irregular trend of fluctuation. The population was high during monsoon months (July to September). The incidence of sand flies was low during summer months (April to June) and minimum in winter months (November to February). It has been found that phlebotomid sand flies have shown a significant positive correlation with the humidity of air.

R6.9.  
1

THE INFLUENCE OF *DACUS TRYONI* ON THE ABUNDANCE OF *DACUS JARVISI* IN CULTIVATED SPECIES OF FRUIT.

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An understanding of the interactions between insects which attack cultivated crops may be crucial to viable pest management. The elimination of an established pest may simply open the way for a minor species to become a pest if its abundance had been influenced previously by competition with the original pest. *Dacus tryoni* (Diptera: Tephritidae) is a major pest of cultivated fruits in eastern Australia. I examined the ecology and behaviour of a minor pest species, *D. jarvisi*, and its interaction with *D. tryoni* in order to explain the current rarity of *D. jarvisi* as a pest of cultivated fruits. I tested two hypotheses; (i) that *D. jarvisi* is competitively excluded from these fruits by *D. tryoni* and (ii) that *D. jarvisi* has preferences for particular native hosts and infests cultivated fruits only when these are unavailable. Laboratory and field cage experiments showed that *D. tryoni* larvae did not influence the survival or growth of *D. jarvisi* larvae in the same fruits nor did the presence of *D. tryoni* adults in the same tree influence the number of progeny produced by *D. jarvisi* females. Field studies of the co-occurrence of these two species within and between patches of a shared host (guava) revealed patterns of distribution and abundance which were not consistent with a competitive interaction between them. Behavioural studies supported the second hypothesis and showed that *D. jarvisi* occurs in cultivated fruits only late in the summer when its preferred native host (*Planchonia careya*) is unavailable.

R6.9.  
2

Population Dynamics: Number of Generations of the Cabbage Looper, *Plutella maculipennis*, Curtis

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During 1976-1977 the population dynamics of the cabbage looper, *Plutella maculipennis* was studied by stage planting in October and December 1976 and January 1977.

The first occurrence of this pest was in November and its highest incidence from mid-December to late March when the temperatures ranged from 17 to 25 °C and the relative humidity from 60 to 85 %; yield losses were 16 to 18 tons per ha. In the period from October to April, 10 generations took place and besides it was observed that the insect pest is affected by several entomophagous insects which parasitize larvae and pupae thus reducing their population. The highest parasitism was observed in the January planting and the highest densities were found in February and March.

R6.9.  
3

# BIONOMICS OF RICE STEM BORERS IN NIGERIA

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Three major lepidopterous borers, Maliarpha separatella Rag., Chilo zacconius Bles., and Sesamia spp., and dipteran borer, Diopsis spp., are distributed widely in three major rice ecosystems (upland, lowland and hydromorphic) and attack the rice plant at various growth stages.

Maliarpha separatella was found to be the predominant species in both ecosystems, followed in upland rice by Sesamia spp. and Chilo zacconius but in lowland rice by Chilo zacconius and Sesamia spp. Lepidopterous borers showed three peaks in both ecosystems. In upland rice the highest peak was in August, whereas in lowland the highest was in October.

Studies of the relation between irrigated rice crop phenology and field infestation by borers showed that Diopsis spp. occurred before 20 days after transplanting (DAT) and continued up to 90 DAT. The lepidopterous borers did not occur until 40 DAT. Maximum population was observed at 80 DAT, the flowering time of variety ITA 212.

6

## R6.9. 4 INDUCED FEEDING PREFERENCE IN Manduca sexta IS A FUNCTION OF TAXONOMIC RELATEDNESS OF FOOD PLANTS.

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Larvae of the tobacco hornworm exhibit the phenomenon of induction of feeding preference; i.e., feeding preferences are influenced by the food plant on which the larvae were reared. We studied the degree to which this effect occurs. Larvae were reared on nine host and three non-host plant species and their food plant preferences were examined in a two-choice preference test. We tested eighteen plant combinations of host vs. host, eight combinations of host vs. non-host and three combinations of non-host vs. non-host species. Variable degrees of induction of feeding preference were found. The larvae induced weakly or not at all with plant combinations of the same species or genus, but induced strongly with species from different plant families. Based on experiments with 1700 larvae, we conclude that the strength of induction in the tobacco hornworm correlates inversely with the taxonomic relatedness of the plant species paired in the test. Analysis of induction data from the literature revealed a similar correlation for fourteen other lepidopterous species. The chemical basis of this phenomenon is being studied using both plant extracts and solanaceous alkaloids.

**R6.9.** FOOD SELECTION BY THE VARIAGATED GRASSHOPPER, ZONOCERUS  
**5** VARIEGATUS L: FEEDING BIOASSAYS USING CROPS AND WEEDS.

DR. OLANIYAN FASORANTI  
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Nigeria.

Acceptability of 46 plants (weeds, shrubs and trees) to first and second instars of Zonocerus variegatus was tested. Over 60% of the plants were accepted in the first hour, 9% after 4 hours and the rest either rejected or nibbled at. The insects seemed to favour hairy plants and fed to a lesser extent on glossy species. Although Z. variegatus performed best when reared solely on Manihot esculenta, most weeds and crops occurring naturally in the savannah regions equally supported growth.

**R6.9.** BIOLOGICAL STUDIES ON THE LEAFHOPPER STREPTANUS  
**6** AEMULANS (KIRSCHB) (HEMIPTERA:CICADELLIDAE).

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The first appearance of Streptanus aemulans (Kirschb) larve was recorded in the field at the end of April and beginning of May. Early larval instars were found on the growing weeds around the orchards. Five larval instars ranged between 24-28 and 28-32 days for males and females, respectively under laboratory conditions (69-75 % and 60-65% R.H.). The last larval instar was longer at least 4 days in comparison to the other instars. Recorded longevity were 60 and 77 days for males and females, respectively.

Two generations per year for S. aemulans were recorded under laboratory conditions.

**R6.9.** BIOLOGICAL STUDIES ON SPECIES OF THE GENUS RHIZOECUS KUNK.  
**7** (HOMOPTERA: PSEUDOCOCCIDAE).

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A survey was conducted on ornamental plant nurseries along the Mediterranean coast, Balears and Canary Islands. Rhizoecus cacticans Hambleton was found on the following plant species: Hylocerius undatus, Mammillaria bocassana, Mammillaria sp., Trichocereus schikendantzi, T. spachianus, Cereus jamacaru, Pachycereus pringlei (cactaceae), Aeonium sp. (Crassulaceae), Cestrum nocturnum (solanaceae), and Pelargonium x hortorum Pelargonium zonale (Geraniaceae). Rhizoecus falcifer Kunk. was found on Lavandula sp. (Labiatae).

Biological studies were conducted under controlled conditions of temperature  $23 \pm 2^{\circ}\text{C}$  and relative humidity 60-80%. Fecundity averaged 78 eggs per female. Development from egg to adult was completed in 42 days. Further information on life cycle is also reported. First description of male of R. cacticans Kunk. is presented here.

**R6.9.** TO THE QUESTION OF MASS OCCURRENCE AND EFFICIENCY OF BLASTOTHRIX CONFUSA, THE PARASITE OF PARTHENOLECANIUM CORNI  
**8** ALOJZ BLAHUTIAK

Inst. of exper. fytopatol. and entomol., Ivanka pri Dunaji, ČSSR

The present work contributes to the explanation of the problem of the occurrence and efficiency of the entomofag Blastothrix confusa ERDŐS, the parasite of the brown scale (Parthenolecanium corni BOUCHÉ) occurring in a mass wuantity on the European continent in the 50's. The main cause of this surprising phenomenon is supposed to be the gradual change of ecological conditions and within them particularly conditions of temperature in the secular cycle 1880 - 1980 in accordance with the increase of their average values. This fact made it possible to suggest that the parasite species B. confusa actually represents an autochtone species of the European fauna. The name B. confusa is to be understood only as a synonymum of another previously existing species which might be identic with the species Blastothrix longipennis.

R6.9.  
9

## SCALE INSECTS (HOMOPTERA: COCCOIDEA) OF EUROPEAN PARKS

ELGA KOZARZHEVSKAYA

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The role of scale insects - pests of forest and ornamental plants - grows from the north to the south. In northern parts they cause damage mostly in greenhouses. Most of dangerous species are introduced ones. In southern regions heavy infestation and damage are observed mainly in open. Economic significance of coccids is larger in those places where the air pollution is higher and pesticides used for plant protection is more intensive. Urban green plantations have a wide number of effective entomophagous capable to reduce reproduction of pests. Methods of biological and quarantine control in urban conditions are perspective.

R6.10.  
1

## THE USE OF AGE PIGMENTS IN ECOLOGICAL STUDIES

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All aerobically respiring organisms studied to-date accumulate auto-fluorescent, intra-cellular pigments. The rate of accumulation is a function of physiological time. The pigment is readily extracted from tissues or whole insects and quantified. Its use in ecological studies is discussed.

P. W. MILES

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*Macrosiphum rosae* (L.) walks off the buds of hybrid tea roses during a 'critical period' coinciding with the opening of the sepals. Over this period, no histological barriers to feeding are apparent and the water status of the tissues depends on environmental variables rather than tissue phenology; changes in soluble carbohydrates, amino and phenolic compounds were similarly unrelated to aphid behaviour, even when major changes in overall tissue chemistry were induced by spraying the bushes with urea.

'Tissue sap' pressed out of stems and sepals showed a significant increase in catechin content after rather than within the critical period. Once expressed, however, sap from buds at the critical stage showed a sharp *in vitro* rise in catechin content over a few hours.

In choice tests, the insects tolerated up to but not more than 0.5 mg/ml catechin in sucrose diets, consistent with the possibility that the insects may be sensitive to the developing capacity of tissue to accumulate catechin in response to their feeding.

## R6.10. ELECTROPHORETIC STUDIES OF RHAGOLETIS CERASI L.

### 3 COLLECTIONS FROM ITALY.

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*Rhagoletis cerasi* collections from several Italian regions were examined and compared in order to study the variability in different cultivars. The different stages of ontogenetic development were investigated.

The comparisons were carried out studying the proteic pattern by polyacrylamide gel electrophoresis at discontinuous pH and in the presence of sodium dodecil sulphate (SDS).

Significative differences were observed in the protein pattern among the collections considered. All the populations show a high degree of variability during ontogenesis. The pupae in diapause reveal a higher individual variability than the adults.



**R6.10.** STRATIBOUND CONSTRUCTION OF NEST BURROWS OF THE SOLITARY  
**4** BEE COLLETES DAVIESANUS (HYMENOPTERA : COLLETIDAE)

DETLEF MADER

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Grain size and lithification or cohesion are controlling the suitability of substrates for construction of nest burrows of the solitary bee *Colletes daviesanus* SMITH 1846. The varying sedimentological characteristics of different rocks both in regional and local extent, especially changing grain size and lithification both in vertical and horizontal direction as well as both randomly and in an ordered manner result in different suitability of the exposed substrates for burrowing finally leading to stratibound position of the nests observed on outcrop walls which is outlined by several case studies.

**R6.10.** PRESENT STATUS AND PROBLEMS OF BUTTERFLY MIGRATION  
**5** STUDIES IN AUSTRALIA.

DR. C. N. SMITHERS

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The Australian butterfly fauna includes many spectacular migrant species, including the well known Danaus plexippus (Monarch or Wanderer).

Conditions in Australia result in special problems in migration studies.

Work over the past 20 years has established the basic patterns of movement for several species which are discussed.

R6.10.  
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ARUN KUMAR

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Cumulative energy budget was determined for the immature stages of Diacrisia obliqua (Wlk.), reared at Helianthus annuus (Linn.) under laboratory conditions (average min. temp.  $15.45 \pm 0.57^{\circ}\text{C}$ , max. temp.  $18.16 \pm 0.25^{\circ}\text{C}$  and relative humidity  $68.82 \pm 1.31\%$ ). The cumulation of energy (Cal./ind./d) in body, consumption, assimilation, egestion and performance values (A.D., E.C.I., E.C.D., C.I. & G.R.) show six epoches, each corresponds to an instar. The estimated energy for these parameter together with performance values varied instar to instar in both the sexes. There have been a linear relationship between energy consumed verses energy assimilated, egested and accumulated in the body. A.D. and E.C.D. in both the sexes at each instar level followed the same pattern. All the parameters resulted into a positive relationship with the age whereas A.D. declines negatively for each larvae in both the sexes.

R6.10. EFFECT OF HIGH TEMPERATURE ( $35^{\circ}\text{C}$ ) ON THE EGG-LARVAE OF  
7 MUSCA DOMESTICA (L.) AND OPHYRA AENESCENS (WIED.).

A.SHAHEIN, M.RABEH. & A.HEGAB. ZAGAZIG UNIVERSITY, DEPT.  
PLANT.PROTECTION. ZAGAZIG. EGYPT.

Investigations were undertaken to study the effect of high temperature  $35^{\circ}\text{C}$  on the egg-larvae of both M.domestica (L.) and O.aenescens (Wied.). High temperature showed remarkable effect on the reduction of the percentage of emergence. It also reduced the number of ovarioles for O.aenescens females. On the other hand, the same temperature reduced strongly dry weight of M.domestica adults. No effect was recorded on the sex-ratio for both species.

**56.1.** ECOLOGICAL ASPECTS OF HOST PLANT RESISTANCE & BIOLOGICAL  
**1** CONTROL: INTERACTIONS AMONG THREE TROPHIC LEVELS

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Physical, chemical, phenological, habitat and biogeographic factors all play their roles in host plant resistance against insect herbivores. Such factors also have direct and indirect effects on the enemies of herbivores (parasites and predators) which act as important biological control agents. Such three trophic level systems must be studied as integrated units, for no two levels in the food web can be understood adequately unless the third level is included. Examples of plant resistance, derived from natural, agricultural and forest ecosystems, are discussed in relation to their effects up the trophic levels.

**56.1.** CONSEQUENCES OF SEQUESTRATION OF PLANT NATURAL PRODUCTS IN  
**2** PLANT-INSECT-PARASITE INTERACTIONS

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Plant natural products can act as modulators of the interaction between herbivorous insects and their insect-parasites. This modulation is partly based upon the degree and type of sequestration of natural products. The type and degree of sequestration are not only regulated by the physico-chemical properties of the natural product, but also are initially highly regulated by the behavioral/physiological/biochemical propensities of the host. This initial and direct acquisition of natural products by the host provides an environment in which the sequestrates can have a profound direct and/or indirect secondary effect upon the fitness of the parasite. It appears that a balance between uptake of nutritive and toxic sequestrates is a determining factor in successful parasitization and perpetuation of the parasite population. Such a balance in plant constituents should be considered in plant-breeding programs where compatibility between host-plant resistance and biological control is desired. Furthermore, an understanding of the interplay between toxic and nutritive plant chemicals is essential in depicting feral insect-parasite relationships.

56.1. MORPHOLOGICAL BASES OF PLANT RESISTANCE: INFLUENCE ON INTERACTIONS  
3 BETWEEN INSECT HERBIVORES AND ENTOMOPHAGOUS SPECIES

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The responses of entomophagous species to plants having morphological resistance have been examined for several plant/herbivore/natural enemy complexes. These resistance factors may affect predators and parasitoids directly, or indirectly through their prey or hosts, also, they can complement, have no apparent effect upon or hinder the effectiveness of natural enemies in insect pest management systems. Recent studies examining the influence of morphologically based resistance on entomophagous species, specifically the effects of glandular pubescent potatoes on natural enemies, have shown complementary interactions.

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56.1. INTERACTION BETWEEN CROP PHENOLOGY AND NATURAL ENEMIES, AND ITS  
4 INFLUENCE ON INSECT PEST POPULATION DYNAMICS

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Evidence of interactions between host plant phenology and the activity and effectiveness of predators and parasitoids is reviewed. An example from cotton, in which age-specific mortality rates of Heliothis spp. eggs and larvae were found to be influenced by a combination of crop growth stage and natural enemies, is described in detail. The relevance of the crop phenology/natural enemy interaction to host plant resistance is discussed.

56.1.  
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## INTERACTIONS OF HOST PLANT RESISTANT GENOTYPES (HPR) AND BENEFICIAL INSECTS IN COTTON

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The interactions of seven predatory species of four orders of insects with insect resistant cotton genotypes were examined. The data demonstrates the direct effects on survivorship of the dispersal stages and on their searching ability and the indirect effects on reproductive potential through lowered fecundity or longevity. The behavioral modification of the herbivore species by allelochemicals in the resistant genotype enhanced microbial control with biological insecticides.

56.1.  
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## INTERACTION BETWEEN RESISTANT CULTIVARS AND NATURAL ENEMIES IN RELATION TO THE POPULATION GROWTH OF THE BROWN PLANTHOPPER, *NILAPARVATA LUGENS*

CHUKICHI KANEDA

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Breeding lines of japonica rice with either of the two resistance genes against the brown planthopper (BPH), *Bph 1* and *bph 2*, were tested in the fields for the ability of suppressing insect population under the two different conditions: (a) rice plants grown inside cheese cloth cages and free from natural enemies of BPH and (b) rice grown in open fields without insecticide application.

In the test (a), BPH could build-up the population on *bph 2* lines almost equal to that on the susceptible check (S) variety, and on *Bph 1* lines almost one half of that of S variety.

In the test (b), the population size of BPH was less than 1 % on *Bph 1* lines, and less than 3 % on *bph 2* lines. Number of spiders in plots of BPH resistant lines was not different from that in plots of S varieties. Besides the effect of predators, the microclimate inside the cages was considered to be favorable to BPH for population increase, and to be physiologically unfavorable to rice plants.

S6.1.  
7 ECOSYSTEM ANALYSIS: PLANT CULTIVARS (HPR), ENTOMOPHAGOUS SPECIES  
AND FOOD SUPPLEMENTS.

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Plant cultivars not only vary in their resistance to phytophagous insects but also vary in their attraction and retention of entomophagous spp. Plant volatiles which attract natural enemies of plant pests should be preserved in selected cultivars or artificially provided if the volatile kairomones are reduced or lost in the process of plant selection. The production of certain plant volatiles which attract entomophagous spp. to their habitats can also vary with age of the plant or crop. Certain secondary plant substances sequestered by phytophagous insects can be beneficial or harmful to predators or parasitoids. The chemical composition of nectars and pollens, the presence or absence of extra floral nectaries and the composition of honeydews excreted by homopterous insects can vary between cultivars. These variations can influence the effectiveness of natural enemies preying on phytophagous insects that attack certain cultivars.

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S6.1.  
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The ratio of pest populations on susceptible and partially resistant plant varieties (the S/R ratio) is frequently higher in the field than would be predicted from an assessment of the varieties under natural enemy exclusion (eg in glasshouse trials), ie the impact of plant resistance becomes magnified. However, it is realistic to assume that, with fewer pests on resistant varieties, absolute (if not percentage) mortality from natural enemies would be reduced by plant resistance. Some reduction in mortality will still give an enhanced S/R ratio in the field, but the effect of the resistance on the population growth of multivoltine pests such as sucking insects will lead to an enhanced S/R ratio in combination with natural enemies with even quite large reductions in mortality. This is borne out by experiments in which the impact of natural enemies of aphids on susceptible and partially resistant varieties has been monitored, though an example can also be cited where the behaviour of a parasite resistant variety can lead to a much reduced S/R ratio.

**S6.1.** MODELING THE INTERACTION OF HOST PLANT RESISTANCE, PHYTOPHAGOUS  
**9** AND ENTOMOPHAGOUS SPECIES

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University of California, Berkeley

Modeling of plant, pest, natural enemy interactions has been an elusive goal of applied and theoretical ecologists. This paper summarizes the progress made to date on modeling multi-trophic systems, and shows how various host plant resistance strategies affect the interactions. A simple general stochastic multi-trophic model is presented wherein calories are the units of exchange at both inter- and intra-specific levels. The physiology of energy acquisition (i.e., functional response) and allocation (i.e., metabolic pool model) to respiration, egestion, and growth and reproduction are incorporated in a simple mathematical model.

**S6.1.** CLOSING COMMENTS: INTERACTION OF ENTOMOPHAGOUS SPECIES AND HOST  
**10** PLANT RESISTANCE

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Pest control by biological methods can be thought of as using density dependent measures such as importation of entomophagous species or utilizing resistant genotypes. While research on these two diverse control methods have been done independently, little research has been completed and reported in the literature where these two control methods have been combined. The influence of parasites and predators combined with host plant resistance will be discussed.

56.2. 1 DIURNAL AND NOCTURNAL FLIGHT ACTIVITY OF SCARABAEINE COPROPHAGES IN TROPICAL AFRICA.

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The yield hour by hour from coprophages pitfall traps have permitted a precise determination of the hours of flight activity concerning 87 savanna or forest species present on the Bateke Plateau in Zaïre (72 *Scarabaeidae*, 13 *Aphodiidae*, 2 *Trogidae*). For certain of these species, as well as for others, data also has been collected in Gabon and the Popular Republic of Congo. We have also taken in consideration the recent data from CAMBEFORT (1982, 1984) concerning the Ivory Coast. Thus, this study concerns more than 400 species.

All of the *Aphodiidae* and *Trogidae* found are nocturnal. As for the *Scarabaeidae*, a detailed analysis has permitted to discern possible common characteristics at the level of nine tribes, at the level of some genus, or, with greater precision, at the level of Bateke Plateau species.

56.2. 2 PERCHING BEHAVIOR IN A NEOTROPICAL FOREST DUNG BEETLE COMMUNITY

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On Barro Colorado Island, Panama, dung scarab populations were monitored by means of foliage censuses, baited pitfall trapping, systematic field surveys of naturally-occurring dung, and experimental manipulations. Of the 36 species of scarabaeines on the island, 15 species were observed on leaf surfaces above the forest floor. This perching behavior most frequently occurs diurnally in the dry and early wet seasons at heights 0.5 to 2.0 meters. Characteristics of the typical leaf percher include: small size (less than 10 mm), non-black coloration, and an overland method of food removal. The most commonly observed scarab on leaf surfaces was Canthon angustatus, a specialist feeder on howler monkey feces, most of which occurred on leaf surfaces above the ground. Leaf perching in C. angustatus was apparently performed by individuals initially unsuccessful at discovering the source of fecal odors. Other species may perch for the same reason and/or to thermoregulate, assess predator density at food sites, or to place themselves in a strata where food odors are most likely to occur.



## 56.2. FIELD ECOLOGY AND REPRODUCTIVE BEHAVIOUR OF THE DUNG BEETLE

### 3 *KHEPER NIGROAENEUS* IN SOUTHERN AFRICA

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*Kheper nigroaeneus* exhibits a variety of specializations enabling it to maintain high population levels in areas where competition for dung is intense. It occurs in summer rainfall areas of southern Africa, where a population has been studied in Mkuzi Game Reserve, Natal. Adults emerge from the soil after the first spring rains, and after 2-3 weeks of feeding, commence breeding. A male moulds a potential brood ball at the dung pad, rolls it away and buries it. If by this time a female has not joined him, he returns to the surface and releases a pheromone. Males also attract females to burrows which contain no dung. The male leaves the brood chamber after 1-2 days. The chamber contains a single brood ball which the female cares for until the new adult emerges, after approximately 12 weeks. This represents the highest parental investment per offspring for an insect. A female can rear a maximum of two offspring per year. The parent female consumes 61% from the outside of the brood ball, which is equivalent to two feeding balls. The egg is laid after one week, but for a further 3 weeks the ovary remains developed, ready to produce another egg. The terminal oocytes are then resorbed. When brood care commences the proportion of males in the above-ground population increases. Breeding activity ceases in late summer, which ensures that development of immatures is complete before winter. Progeny which emerge after autumn rains feed but do not breed. Adults (parentals and filials) which bury in the soil to overwinter have a reduced metabolic rate, empty guts and a high fat content.

## 56.2. ECOLOGICAL EVOLUTION OF DUNG BEETLE NESTING BEHAVIOR

### 4

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Among the principal features of the ecological strategy of Scarabaeinae is food relocation behavior, by which an adult sequesters a private store of food underground. Food relocation behavior solved two important ecological problems for ancient dung beetles: how to avoid competition with other coprophages and how to protect their perishable food from rapid spoilage. This behavior proved to be a preadaptation crucial to the evolution of their reproductive strategy -- food relocation was the basis for nesting behavior, in which food was relocated for use by progeny, not for adjust consumption. The subsequent evolution of nesting behavior followed a central adaptive theme: progressively higher parental investment in each offspring. Present variation in nidification by Scarabaeinae can be viewed as comprising several nesting patterns, each of which embodies features interpretable as solutions to special ecological problems. In the more primitive patterns, nidification is a simple extension of feeding behavior; each food store is provided an egg and becomes a simple nest. More advanced patterns exhibit male-female cooperation and compound nests (those containing more than one offspring); these features are responses to the ecological imperative to increase reproductive output by increasing the efficiency at exploiting large sized food sources. The advent of compound nests resulted in a secondary ecological problem -- the potential for competition and other negative effects posed by crowding. Further innovations were responses to the adaptive advantages of increasing the degree of protection of individual offspring; these included brood ball construction and direct care of the brood by the female. Each of the major behavioral adaptations (compound nests, etc.) undoubtedly arose several times during the phylogeny of Scarabaeinae.

6.2.

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## LOCAL AND REGIONAL SPECIES ASSEMBLAGES OF APHODIUS IN EUROPE

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In northern Europe - the British Isles and Fennoscandia - Aphodius comprises practically all the numerous dung beetles (Scarabaeidae) but in southern Europe both Aphodius and Scarabaeinae are abundant. This paper deals primarily with the community in cattle dung in northern Europe, where local species assemblages typically consist of ca 15 species. Most species are clustered into seasonally coexisting guilds of univoltine species (e.g. pusillus-ater-fossor, rufipes-rufescens) though some multivoltine species occur (e.g. finetarius). Special attention is given to the rarest species in local communities, which appear to have a maximum density of at least 0.5 to 1 beetle per dropping. Changes in species composition at different spatial and temporal scales are discussed. Movements between droppings are described, with examples of density-dependence and different stay times in droppings.

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6.2.

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COMMUNITY STRUCTURE AND ROLE IN DUNG BURIAL OF FOREST AND SAVANNA  
SCARABAEIDAE DUNG BEETLES IN THE IVORY COAST

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The 286 Scarabaeidae s. str. from the Ivory Coast were divided into ball-rollers and burrowers. Most of the ball-rollers are small, diurnal and are attracted to the nitrogen-rich excrements of smaller omnivorous mammals. The burrowers are either large, nocturnal, and attracted to the large herbivore dung pads that are rich in complex glucides, or they are small, diurnal or nocturnal, opportunistic and capable of exploiting almost any type of excrement as well as carrion. In both savanna and forest, body size of Scarabaeidae depends upon the mammalian fauna, but savanna habitats have more species and more biomass per unit surface area than do forest habitats. Scarab communities in Guinean savanna bury one metric ton of dung per hectare per year ; in forest, dung burial rate is ten times lower.

56.2.  
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## THE EFFECT OF COMPETITION AND HABITAT ON THE STRUCTURE OF DUNG BEETLE COMMUNITIES IN SOUTHERN AFRICA.

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Dung beetle species can be allocated to one of five functional groups on the basis of the way in which they use dung; namely i) ball rolling: a dung mass 5-20 times the beetle's liveweight is rolled away and buried at a distance from the pad, ii) rapid dung burial: a dung mass 100 to 500 times the beetle's liveweight is buried under the pad within 24 h of pad colonisation, iii) slow dung burial: a dung mass up to 1000 times the beetle's liveweight is buried under the pad during a period of up to 3 weeks, iv) the endocoprid habit: breeding occurs within the dung pad and v) the kleptoparasitic habit.

A method for quantifying community composition (species) and community structure (functional groups) using biomass has been developed. Within soil types, dung beetle communities usually have a high degree of similarity in community structure (relative abundance of functional groups) but often a low level of similarity in species composition.

Many species in southern Africa show marked associations with particular soil types and a preference for bushveld or grassveld. The relative abundance (or biomass) of species within localities reflects community structure and results from their ability to compete for dung and to produce viable offspring. Competition for dung is often intense and large ball rollers and fast burying tunnellers are the most effective competitors for dung at the pad. However, dung burial, especially by large ball rolling species appears to be restricted by soil hardness and so many such species are restricted by sandy soil systems.

56.2.  
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## EFFECT OF ADULT SIZE AND FEEDING BEHAVIOUR OF DUNG FEEDERS ON DUNG DISPOSAL IN DIFFERENT SOILS AT RAWALPINDI, PAKISTAN

A.I. MOHYUDDIN AND R.K. SIDDIQUI

Studies were made on the role of scarabaeids in rendering dung pats unsuitable for fly breeding. On the basis of their size, these have been divided in four groups:

Group A includes species measuring 30-50 mm. Heliocopris gigas is more abundant in sandy soils and H. bucephalus in hard soils. These species bury dung in the soil beneath the droppings.

Group B includes species measuring 20-29 mm. Catharsius spp., Onitis virens and O. lama are more abundant in dry river beds and Scarabaeus gangeticus and S. andrewesi, which have the habit of rolling dung away from the droppings in hard gravel soils.

Group C comprises of species measuring 10-19 mm. Onitis subopacus, O. philemon, Onthophagus bonasus, O. gazella, Copris sarpedon and Scarabaeus devotus are equally abundant in hard clay and sandy soils. Onitis castaneus, O. humerosus and Onthophagus pactolus are more abundant in sandy soils. Geotrupes spp. can bore very hard gravel soils and are confined to the mountains.

Group D comprises species measuring 1-9 mm and Onthophagus spp., Euoniticellus spp., Drepanocerus spp. and Aphodius spp. are included. Most of these bury dung in the soil making up to 20 cm deep burrows. These species seem to contribute very little in dung disposal.

Suitability of various scarabaeids, for different soil types in relation to their feeding behaviour and size has been discussed.

### 56.3. EVOLUTION OF INSECT MIGRATION

1

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Insect migration varies considerably within and among species and is influenced by a complex of interacting environmental and genetic factors. The evolution of migration is determined by the action of natural selection on those interactions. The range of outcomes of such evolution includes complete macroptery with variation in flight performance, the histolysing of flight muscles during sedentary periods, and wing polymorphism. I shall discuss factors leading to these outcomes including relationships between migration and diapause. In addition some insects display migration-life history syndromes involving phenotypic and genetic correlations among migration and life table characters. These syndromes are revealed by sibling analysis and laboratory selection experiments. Running through insect migration "strategies" is a common theme of adaptation to shifting environments.

### 56.3. HORMONAL REGULATION OF FLIGHT BEHAVIOR AND FLIGHT FUEL UTILIZATION IN ONCOPELTUS FASCIATUS

2

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A number of neuroendocrine products are involved in the control of flight behavior and flight fuel metabolism in insects, including the adipokinetic hormone (AKH), juvenile hormone (JH), and octopamine. In Oncopeltus fasciatus, the migratory milkweed bug, juvenile hormone stimulates flight behavior and is also involved in the control of flight fuel mobilization. Oncopeltus utilizes both lipid and proline as flight fuel. Proline is important in the initial 90-120 min of long-duration flight and in short flights, while lipid is necessary to support long-duration, presumed migratory flight. The exact metabolic role of proline is still unclear in this species. However, the first hour of long-duration flight as well as short-duration flights are energetically more expensive than later stages of long-duration flight. Proline metabolism during the first 90 minutes of flight may be necessary to support the higher metabolic demands at this time. JH may be involved in switching from proline-lipid supported flight to entirely lipid supported flight in migrants.

56.3.  
3

### THE ENDOCRINE CONTROL OF FLIGHT METABOLISM

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The roles of hormones in integrating the supply to and utilization of fuel by the flight muscles will be described in a number of insects, but special attention will be directed towards locust flight metabolism. In particular, the control of diacylglycerol mobilisation from the fat body, the transport of lipids in the haemolymph, and their utilisation by the flight muscles will be discussed in relation to the decapeptide, adipokinetic hormone. Some comparisons will be made between locust flight metabolism and exercise metabolism in mammals: parallels will be drawn between the metabolic strategies adopted, the mechanisms employed, and the hormonal integration of the associated processes.

56.3.  
4

### THE FLIGHT SOUNDS OF INSECTS

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Sounds produced by insects in flight will be illustrated. The significance of these sounds as sources of information rather than by-products of the mechanics of flight will be reviewed. Examples of the use of flight sounds by some groups of insects will be described. The sensory equipment used to locate the source of such sounds, for example in mating, will be discussed.

56.3. ARTHROPOD DISPERSAL AS REFLECTED BY FALLOUT ON VOLCANIC PEAKS OF THE  
5 PACIFIC NORTHWEST, USA

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The volcanoes of the Pacific Northwest are alpine islands set in forested and agricultural lowlands. The composition, biomass and phenology of arthropod fallout on their upper slopes reflect patterns of dispersal from lowlands. Pitfall, window, and other sampling trap data from Mt. Rainier snowfields and the blast zone of Mt. St. Helens provide a quantitative index of wind-borne transport from lowlands. Diptera comprise 70% of alpine arthropod fallout, followed by Homoptera (10%), Thysanoptera and Hymenoptera (5% each). Ten others orders are frequent. Over 40 species of spider arrive as ballooners. Traps designed to measure true flux of airborne arthropods on Mt. St. Helens indicate a mean net increase of arthropod biomass of about 7.5mg/sq m/day through the summer months.

Comparable fallout on Mt. Rainier provides a resource base for a nocturnal snowfield foraging fauna between 2 and 3,000m.

Supported by National Science Foundation.

56.3. FLIGHT DIRECTION IN RELATION TO WIND  
6

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For a migrating insect, a serious risk is to return by chance to the same area where it hatched. The migrants have several possibilities to avoid this: 1) by visual orientation using astronomic marks, the plane of polarization of polarized light, or landmarks, 2) by using magnetic fields or 3) by flying downwind or upwind. The use of orienting cues may vary between individuals of the same species, during the life of a single individual or even during a single migration.

Changes of the direction of a migration according to the wind direction, in subsequent days or in the same day, show predominance of wind orientation over compass orientation. At the northern latitudes, long-range migrations of e.g. Lepidoptera regularly arrive with air currents. More local flights of e.g. wasps and bumble bees may proceed against the wind. The importance of directed flights is seen in the fact that the upwind migrants lose the carrying power of the wind and must compensate for the displacement caused but nevertheless fly upwind.

### S6.3. 7

#### THE USE OF POLARIZED SKYLIGHT IN INSECT NAVIGATION

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No insect species has yet been shown to use skylight patterns as a compass during dispersal and migration. All we know about celestial navigation in insects has been derived from studies on foraging and homing. In this context, central-place foragers like bees or ants use a celestial compass as part of a dead reckoning (path integration) strategy. Even though path integration is unlikely to occur during dispersal and migration, celestial patterns (spectral and polarization patterns) could be used either to select an innate course or, more probably, to stabilize and maintain a course that has been selected by other means. These possibilities are discussed against the background of what is known about the perception of polarized light in insects.

### S6.3. 8

#### FLIGHT BEHAVIOUR IN MIGRATING BUTTERFLIES

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Three species of butterflies, Danaus plexippus, Nymphalis antiopa, and Vanessa atalanta, all minimize energy expenditures and reduce wear on the wings during their fall migration by soaring in thermals when conditions are favourable. Thermal soaring requires specialized behaviour to exploit the updrafts while avoiding being drifted off course. In southern Ontario, Canada, D. plexippus, the most intensively studied of the three, was found to exhibit a wide range of flight behaviour that allowed it to both soar in thermals and maintain its preferred SW course when winds were from the NE, E, and SE. When winds were from the W, NW or N, the butterflies still soared but allowed their course to be drifted to the S and SE. A hypothesis was advanced that assumes that butterflies that migrate during the late summer and fall, and which employ soaring flight are being selected for (1) maintaining species-specific preferred courses, (2) minimizing energy expenditures and wing wear, (3) migrating under the greatest possible range of wind conditions, and (4) quickly evacuating the higher latitudes. The hypothesis predicts that for each species, the preferred course, the pattern of compensation for crosswinds, and the pattern of circling in thermals will vary with latitude and geographic location in specific ways. A test of some of the predictions of the hypothesis was performed with one season's data for D. plexippus migrating in southern Texas. The flight behaviours of the butterflies were consistent with the predictions.

## 56.3. LUNAR PERIODICITY OF INSECT FLIGHT AND ITS ADAPTIVE SIGNIFICANCE

9

W. DANTHANARAYANA

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Lunar periodicity of insect flight, studied with suction traps at 0, 2.5, 5, 10 and 20m from the ground, is seen as a trimodal flight curve within the synodic month. Behavioural studies with light traps and an activity meter showed that night flying insects have increased responses to dim polarized light than to dim unpolarized light. This behaviour also occurs during the lunar month due to the variable content of polarized moonlight. Consequently two of the flight peaks coincide with the moonlight polarization peaks at 5-7 days before and after new moon. The third flight, peak occurs at or near full moon, when there is less polarized but more intense moonlight. The hourly vertical density profiles and their calculated slopes show that during the pre- and post-new moon flight peaks insects fly upwards, presumably using polarized moonlight as a cue. This enables them to enter the upper levels of air beyond 70m where sufficient wind to enhance migratory flights. At full moon large numbers of insects fly closer to the ground, but with a single period of upward flight at night. It appears that the lunar rhythm of insect flight, which is closely associated with the periodicities of polarization and illumination of moonlight, is an adaptive mechanism for migration.

6

## 56.3. ROLE OF MIGRATION IN EXPLOITING PATCHY AND TIME-VARYING RESOURCES.

### 10 DYNAMICS OF A SEED - SEED PREDATOR SYSTEM.

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Seeds usually form a patchy and variable resource, and migration is an important adaptation for many seed feeding insects to track their variable food supply. We have studied a perennial plant Vincetoxicum hirundinaria (Asclepiadaceae) and its two specialized seed predators Euphranta connexa (Diptera, Tephritidae) and Lygaeus equestris (Heteroptera, Lygaeidae) in Sweden. Densities of pods, flies and bugs were monitored over several years in over forty plant patches, and migrations of bugs between habitat patches were followed by marking experiments. Local population extinctions, migrations and colonizations by seed predators are frequent events in this system based on highly unpredictable resources. It will be shown how migration enables insects to survive in this archipelago of temporally and spatially variable habitat patches.



56.3.  
11

## GENETIC AND ENVIRONMENTAL FACTORS IN INSECT MIGRATION

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Environmental cues predominate in regulating insect migration in the temperate zone where they are reliable indicators of impending climatic conditions and habitat suitability. Although important components of this environmental input, notably changing photoperiods, may be absent or unreliable in the tropics, others (e.g. crowding, diet) can provide adequate cues for migration to achieve colonisation of new or extended habitats associated with seasonal rainfall. Species in which environmental inputs regulate migration show high additive genetic variance for thresholds of response to these cues and for flight capacity, allowing selection to 'fit' the responses of populations to local conditions.

The comparative scarcity of unequivocal evidence for flight polymorphisms determined by genetic differences confirms the prevalence of environmental control but may also reflect the relative lack (with notable exceptions) of comprehensive studies of factors influencing migration in tropical insects. Evidence is now emerging that discontinuous variation in the capacity for migratory flight, based on genetic differences, is maintained in the East African population system of the armyworm *Spodoptera exempta*. Genetic and environmental factors influencing migration in this species may provide insights into migration by other non-diapausing tropical/subtropical moths, some of which make seasonal incursions into the temperate zone.

56.3.  
12

## WING POLYMORPHISM AND MIGRATION IN PLANTHOPPERS: THE ROLE OF HOST PLANTS

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Several species of wing-dimorphic planthoppers occur abundantly on the vegetation of the intertidal marshes of eastern North America. Both winged and flightless morphs occur, but their proportions differ dramatically among populations and species. Factors that determine wing-form and affect density-dependent migration are discussed as are the ecological and behavioral characteristics of wing-morphs. Spatial and temporal variation in host plant nutrition and architecture is considered as a major factor that shapes planthopper life history and influences patterns of wing-dimorphism and migration.

### 56.3. DISPERSAL IN APHIDS, A PROBLEM IN RESOURCE ALLOCATION

13

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Although aphids feed directly from the circulatory system of plants they are nevertheless food limited. Each morph in the life cycle of an aphid assigns different levels of resource to defence, dispersal, reproduction and survival.

The trade-off between dispersal, reproduction and survival will be illustrated by reference to the cost of the development and maintenance of wing muscles, the relationship between reproductive investment and migratory urge, and the relationship between reproductive investment and survival of the offspring of alatae: the colonizers.

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### 56.3. DISPLACEMENT OF AGRICULTURAL PEST INSECTS

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Insect pest movement within and among agroecosystems is now being emphasized as a major component of the population dynamics of pest species and thus an important consideration in integrated pest management. Local movement among fields, crops, uncultivated hosts, and overwintering refugia, as well as long-range migrations, are being quantified for numerous species. Recent models of movement consider not only the biological attributes of the pest, but also the physical and biological structure of the agroecosystem as it impacts these movements. Examples are presented for several distinct species of the research necessary, model formulations and results of varying ecosystem structure.

S6.3.  
15

### Insect Dispersal Studies with Radar

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Radar provides a unique method of observing individual insects in natural flight at ranges of up to 2Km, and yields measurements of timing of flight, aerial density, displacement and orientation. Its particular value in migration studies is illustrated by the results of radar observations of moths of the African Armyworm Spodotera exempta. These results showed that almost all the successfully emergent moths from gregarious larveal populations embark on nocturnal migratory flights at heights of several hundred metres and fly for at least 20 Km.

Recent use of short wavelength (8 mm) radar has demonstrated that the technique may be usefully applied to the study of the individual insects weighing as little as 1 mg.

S6.3.  
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### RADAR OBSERVATIONS AND COLLECTIONS OF INSECTS IN THE GULF OF MEXICO

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Over 400 species of insects were identified from captures in black-light traps operated on unmanned oil platforms located up to 160 km offshore in the Gulf of Mexico. In a follow-up study, an entomological radar mounted aboard a research vessel detected insects in the Gulf as far as 315 km from shore. Insects representing six orders and twelve families were collected from the ship's deck. Insects were detected during the day and night and numbers varied with distance from shore, and with the winds. These observations were made during relatively mild synoptic weather conditions and suggest that movements of insects between Mexico, Cuba and the United States could easily occur. Strong winds could result in movements across wider portions of the Gulf.

**56.3.** NIGHT VISION EQUIPMENT AND TECHNIQUES FOR STUDIES OF NOCTURNAL BEHAVIOR  
**17** IMPORTANT TO INSECT FLIGHT, DISPERSAL, AND MIGRATION

P. D. LINGREN<sup>1</sup>, J. R. RAULSTON<sup>2</sup>, T. J. HENNEBERRY<sup>3</sup>, AND A. N. SPARKS<sup>4</sup>  
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Sources, costs, strengths and weaknesses of various types of night vision equipment, suitable for viewing insects, are discussed. Techniques for using the equipment to observe and record adult emergence, low level flight, feeding, oviposition, pheromone secretion, mating, mating status, generation age structure, and impact of various population suppression techniques are discussed and related to movement of adult insects. Primary emphasis will be placed on Heliothis spp. and certain other noctuid pest species.

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**56.3.** ECOLOGICAL ASPECTS OF MIGRATION OF THREE PESTIFEROUS LEPIDOPTERA IN  
**18** THE SOUTHERN UNITED STATES AND NORTHEASTERN MEXICO

RAULSTON, J. R., PAIR, S. D., SPARKS, A. N., and WESTBROOK, J.

Survival strategies of 3 major pestiferous lepidoptera, the fall armyworm, the corn earworm, and the tobacco budworm, appear to differ in the context of movement when comparisons are made between Southeastern U.S. populations and those developing in South Texas-Northeastern Mexico.

Population dynamics studies involving the fall armyworm in the Southeastern U.S. indicate that spring movement of this insect is correlated with environmental conditions that are conducive to the planting and development of major host plant populations such as corn. As favorable conditions for survival prevail, a progressive range extension of populations occurs during the season until areas as far north as Canada are invaded. A concomitant population "freeze back" occurs in late fall from its northern ranges associated with adverse host plant and environmental conditions.

Climatic conditions associated with the semi-arid subtropical areas of the Lower Rio Grande Valley of Texas and Northern Mexico appear to be more conducive to a long range spring migration of the corn earworm and tobacco budworm as well as the fall armyworm from the area. The chronological aspects of host plant availability, insect population development, and environmental conditions conducive to such migration are discussed. The possibility of a southward migration back into the region in late fall are also addressed.

## S6.4. LIFE-CYCLE STRATEGIES OF INTERTIDAL MIDGES LIVING BETWEEN SUBTROPIC 1 AND ARCTIC LATITUDES.

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One aspect of life cycle strategies is the correct coincidence between the reproduction period and adequate conditions in a fluctuating environment. Intertidal insects are confronted not only with seasonal and daily climatic fluctuations, but additionally with the strong influences of the tides. Species with long-living adults may find appropriate situations on the sea-shore by some kind of opportunistic behavior. However, species with short-lived adults have to program their development to coincide with a situation recurring only every two weeks at a distinct time of day. The timing of emergence by physiological clocks has been determined in several geographic populations of *Clunio* species in relation to season, lunar-month and time of day as well as to the geographic adaptation to reliable environmental time cues. The importance of developmental stages (imaginal disc formation, pupation, eclosion) in the control of life cycle duration and their coupling with the clocks will be discussed.

## S6.4. VARIATION IN CRICKET LIFE CYCLES AND OVIPOSITOR LENGTHS 2

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Among 11 Pteronemobius spp in Japan, ovipositor length shows inter-specific variation relating to habitat types such as sandy beach, grassland, forest, marsh, etc, and suggesting selection for an optimal length in each habitat. However, P. mikado and P. nigrofasciatus show parallel variations in ovipositor length along the latitudinal gradient. Although the northern univoltine and southern bivoltine populations of these two species occupy similar habitats, ovipositor is shorter in the latter than in the former and still shorter in closely related subtropical species that scarcely or only partially enter egg diapause. Ovipositor length is thus correlated not only with habitat conditions but also with egg's diapause characters. The environmental stress increasing with time in the egg stage is probably involved in the selection of ovipositor length. Life cycle strategy can thus interact with morphological traits to establish an integrated system of adaptation.

**56.4.** ECOLOGICAL REGULATION AND INTRASPECIFIC VARIABILITY OF  
**3** DIAPAUSE IN FLIES

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The winter adaptations of insects are the important component of their life-cycles. In flies belonging to the families Calliphoridae, Sarcophagidae, Muscidae (Diptera, Cyclorrhapha) the larval, pupal and imaginal diapauses are found. The typical peculiarities of three types of diapause, the role of photoperiodic and temperature reactions in diapause induction and termination and also the maternal influence on the larval diapause in the progeny of females in calliphorids have been studied experimentally. The correlation of larval and imaginal diapause during the ontogenese in *Calliphora vicina* and intraspecific variability of imaginal (*C. vicina*, *Protophormia terraenovae*) and larval (*C. vicina*) diapause have been considered.

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**56.4.** OBSERVATIONS ON POLYMORPHISM IN LARVAL HIBERNATION STRATEGY  
**4** OF ZYGAENIDAE (INSECTA, LEPIDOPTERA)

WOLFGANG WIPKING

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All german *Zygaena* species (Subfam. Zygaeninae) investigated up to now are characterized by a larval diapause. The development time of some of the species differs intraspecificly and ranges from one to several years because the number of dormancies may vary among the specimens of a progeny. The reason for such a polymorphism in larval dormancy may be the "spreading of risk". At the northern fringe of the distribution-areas, the univoltine specimens may build up large local populations in years with optimal conditions, while those with a developmental time of two years or more guarantee the survival of the population under worse conditions. Populations of *Z. trifolii* (51°N) show the first obligatory dormancy under different photoperiodic conditions either in the L<sub>3</sub>, L<sub>4</sub> or L<sub>5</sub> stage characterized by a special larval morph. The environmental factors for the termination of the diapause as well as for the induction of a further diapause after a short period of feeding and growth are still unknown. Populations from Spain (39°N), however, develop without dormancy in LD ≥ 15/9. In the other european subfamilies (Chalcosiinae: *A. infausta*; Procrinae: *R. pruni* and *P. statice*) only a physiological rest (quiescence) may occur at any time as a facultative and reversible stop of development as an response to lower temperature conditions.

## 56.4.5. EXAMPLES OF LIFE-CYCLE STRATEGIES IN BOREAL DROSOPHILIDS

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A typical example of life-cycles among northern drosophilids is that of *Drosophila littoralis*. The population spends the winter as pre-reproductive, unmated adults. In May, the flies weak up, migrate along shores, and reproduce. The reproductive life span of overwintered individuals extends to July. It seems to be justified to call it "iteroparous". In the beginning of August, the newly emerged adults stay in "photoperiodic quiescence", which then turns to the stage of hibernation.

Another interesting type of life cycles is that of *Chymomyza costata*, characterized by larval hibernation. In the north, populations contain two principally different hibernation mechanisms. Facultative photoperiodic diapause and obligatory diapause are both present. The obligatory diapause is polymorphic, and of course it masks the facultative diapause. These mechanisms seem to be genetically separate.

Using these two species as examples, we have tried to develop semirealistic computer models to study the significance of different life-cycle parameters within the framework of the extreme seasonal oscillation of our climate at the latitude 65°N.

## 56.4.6. GENETIC VARIABILITY OF PHOTOPERIODISM IN MECOPTERA AND LEPIDOPTERA

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Natural selection favours a maximal exploitation of the length of favourable environmental conditions to produce successfully as many generations as possible. This is best achieved by an optimal synchronization of the number of generations with the environmental conditions. During the course of the year a critical point of time exists for each individual. After this point only diapause makes survival certain. The significance of day-length threshold and critical number of days for the determination of the critical point of time is shown and discussed. The critical point of time fluctuates unpredictably. In this connexion the adaptive significance of the genetic variability of day-length thresholds and critical number of days and the genetic linkage of these two factors in *Panorpa* is explicated. It could be shown by inbreeding experiments with *Panorpa vulgaris*, that each individual shows its innate day-length threshold and its innate critical number of days. The variation reflects the frequency of correlation of a distinct day length and distinct number of days with the critical point of time in the past. The "compensation" of a lower number of days by a higher day lengths as another form of linkage of these two factors is demonstrated in *Pieris brassicae*. *Mamestra brassicae* display an aestivation diapause. Aestivation is only a retarded development. It is shown by inbreeding experiments, that aestivation is determined by an innate day-length threshold. Not a fixed day-length threshold and critical number of days is inherited but rather a "reaction norm". The strategy of flexible response is discussed.

56.4.  
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# DIAPAUSE STRATEGIES IN THE AUSTRALIAN PLAGUE LOCUST, CHORTOICETES TERMINIFERA WALKER

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Chortoicetes terminifera is a multi-voltine species with a facultative egg diapause. Diapause occurs in late-anatrepsis and is confined largely to eggs laid in autumn. Diapause induction and the depth of oviposition are determined mainly by daylength. Insects exposed to medium daylength, or a decrease in daylength, produce eggs that can enter diapause; those subjected to either short or long days, or to an increase in daylength, lay only non-diapause eggs. Diapause inception is determined by temperature and moisture conditions experienced during the pre-diapause stages. Eggs in which diapause is averted normally hatch before winter, but low temperatures and short photoperiod delay nymphal development at the third nymphal instar. Embryonic diapause, combined with drought-induced quiescence, which can occur before and/or after diapause, facilitates the survival of C. terminifera in environments that might otherwise be unsuitable for permanent habitation.

56.4.  
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## EVOLUTION OF THE TIMING OF DIAPAUSE INDUCTION

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The timing of diapause induction relative to some catastrophic event, such as the first hard frost in the autumn, is an important decision. If an insect switches to diapause too early in the season, its fitness is reduced because it could have reproduced with enough time to replace itself in the overwintering population. On the other hand, switching too late reduces fitness because the insect commits itself to reproduction without enough time to replace itself before the end of the season.

I shall discuss recent theoretical findings concerning the evolution of the distribution of switching times in a population. Important variables that should be considered when analyzing the evolution of this trait are the following: demography, including age-specific survivorship and fecundity, and age structure; the mating system; heritability of the switching time; and yearly variation in the end of suitable growing conditions.



## 56.4. THE EVOLUTION OF INSECT LIFE CYCLE SYNDROMES 9

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Insect life cycles display a number of characteristics which allow them to adjust to environmental fluctuation and variation. These include diapause, aestivation, migration and variation in life table traits such as development rates and age at first reproduction. I shall examine the relation between environment and life history variation from the perspective of life cycles as complex adaptations. The analysis will consider both phenotypes and genotypes, including aspects of genetic correlation structure. The discussion will include comparative studies of geographic variation among populations within species and the possible causes of differences among species with respect to the match between life cycles and environmental "templates".

## 56.4. ARE THE ANTS GOOD STRATEGISTS OR JUST INSECTS ! 10

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There are many ways in which ant's colonies develop and grow. During foundation time, some very interesting "adaptations" occur for example in species like the fire ant (Solenopsis invicta Buren). These adaptations or "strategies" allow the colony to sometimes develop into highly sophisticated system, like super-colonies of Formica species (F. lugubris Zett, F. exsecta Nyl in the Swiss Jura; F. yessensis Forel in Japan). Reaching this stage of evolution, some drastic changes occur in diet, production of sexuals, behavior etc... Through these examples, the author discusses some ideas at the light of recent discoveries and results, including pheromonal influences.

56.4.  
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VARIATION IN DEVELOPMENT TIME FOR CICADAS

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Cicadas generally require a long time to complete development, ranging from 2 years for undisturbed populations of Mogannia iwasakii to 17 years for the periodical cicadas, Magicalicada spp. Two hypotheses are discussed to account for these lengthy periods of maturation. (1) For populations that are not expanding, there is no demographic advantage to a rapid development, particularly if prolonged development is associated with increased size and increased fecundity. A long development may be favored because the schedule of survivorship for cicadas is very steep; the probability of mortality at establishment is great and becomes small for the remainder of nymphal life. (2) Cicada nymphs feed on root xylem fluid, an extremely dilute source of nutrition. Given that large body size is favored, cicadas may require a prolonged period of development to attain their adult size because of nutritional constraints. In sugarcane and asparagus plantings in Okinawa and Mexico where crops receive heavy applications of fertilizer, two cicada species have been reported to develop in only a single season.

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56.4.  
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MOSQUITO MATERNITY: THE SIGNIFICANCE OF EGG BROODING IN THE LIFE CYCLE OF TRICHOPROSOPON DIGITATUM

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Discarded cacao husks which collect rainwater are the favored habitats of Trichoprosopon digitatum in lowland tropical rain forest of eastern Venezuela. Eggs of this mosquito species float vertically and are held together as a raft by physical forces. From the time of oviposition until hatching in husks (ca 30 hours), egg rafts are guarded by females between their mesothoracic legs. Field and laboratory experiments confirm the survival value of brooding behavior for protecting eggs from environmental perils such as heavy rainfall, which may wash unattended eggs from husks. The evolution of egg brooding among mosquitoes is discussed in relation to the habitat of the immature stages, longevity of adult females, and vulnerability of the egg.

## 56.4. EVOLUTION OF LIFE-HISTORY TRAITS IN THE PITCHER-PLANT MOSQUITO

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The mosquito, Wyeomyia smithii Coq., completes its pre-adult stages only within the water-filled leaves of the purple pitcher plant, Sarracenia purpurea L. Resources for the mosquito in this restricted habitat consists of prey captured by its carnivorous host. In nature, southern populations experience severe density-dependent development and pupation success. Density-dependent constraints abate with increasing latitude. Life-history traits determined under quasi-natural conditions in the laboratory reveal several patterns. First, density, per se, rather than geographic origin, has the greatest effect on capacity for increase ( $r_c$ ) and its components, generation time and replacement rate. Second, among 12 populations from the Gulf of Mexico to Canada (24° of latitude),  $r_c$  at high densities as well as intra-specific competitive ability was positively correlated with  $r_c$  at low densities. Third, only southern females bite and rely on blood for their second and subsequent batches of eggs. However, it is the females resulting from nutritionally replete rather than deprived larval backgrounds that are the most avid biters and realize the greatest increase in gross lifetime fecundity. These results indicate that evolution of life-history traits in W. smithii has produced real but idiosyncratic adaptations rather than modifications of "classical" traits such as capacity for increase and its components as predicted by either bet-hedging or r- and K-selection.

## 56.4. LIFE CYCLE STRATEGIES AND PLANT SUCCESSION

14

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Insect life-cycle strategies are influenced by habitat permanence, habitat complexity and resource availability and diversity. These factors have been measured in experimental sites of known successional age in Southern Britain. Early successional sites are represented by harrowed land left to recolonise naturally for periods from 1-7 years. An area of permanent pastureland represents a mid successional site and a predominantly birch woodland a late successional site. The life-cycle strategies of a wide range of insect taxa are compared at different stages in the plant succession. Changes in the size of the organism, generation time, dispersal ability, overwintering stage and reproductive potential are considered, in addition to variation in niche specialisation. The ecological significance of these characteristics are discussed.

6.4.  
15

r- AND K-SELECTION AT TWO TAXONOMIC LEVELS IN THE PIERINE  
BUTTERFLIES OF NORTH AND SOUTH AMERICA (LEPIDOPTERA: PIERIDAE)

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Parallel evolution has occurred in the Pierini in the Holarctic and in cool-temperate South America. The ecological equivalents of Pieris in South America are the taxa of the Tatochila sterodice species-group. Both taxa have apparently undergone adaptive radiation during and since the Pleistocene. In North America, reproductive strategies are correlated with habitat preference at the level of species-group (Pieris napi vs. Pieris callidice grp.) with little evidence of local or latitudinal differentiation. In the T. sterodice group, however, reproductive strategy - habitat correlation is at the level of species or even subspecies. Data from many geographic populations in both hemispheres are compared.

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56.4.  
16

THE EVOLUTION OF WING POLYMORPHISM IN INSECTS

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Many insect species are characteristically polymorphic with respect to the possession of flight capability, generally recognisable by the presence of long- and short-winged forms. Experiments suggest that in some cases brachyptery is dominant, the trait being determined by a single locus with two alleles. In other cases, perhaps most, the polymorphism is controlled by a polygenic system. It is argued in this paper that while the origin of brachyptery may be due to a single gene mutation selection will, in general, strongly favour the evolution of a polygenically controlled trait. A simple model is presented that can account for the effects of photoperiod and temperature on the expression of the trait. The generation of different ratios of long- and short-winged morphs under the influence of changes in photoperiod and temperature may be timed to occur at specific times during the year. This timing is generally assumed to be of adaptive advantage. However, in some cases it may represent a simple mechanism for the generation of short- and long-winged morphs.

## 56.5. 1

### WHAT CAN CARABID BEETLES TELL US ABOUT DYNAMICS OF POPULATIONS?

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From year-round pitfall-sampling in Drenthe at 89 sites (a total of 290 year-samples) reliable data on the fluctuations of numbers in local population of 64 carabid species could be obtained and be compared with the expectations from best-fitting null-models (fluctuations occurring at random). From these tests it could be derived that:

1. The frequency distribution of coefficients of net reproduction ( $R$ ) of local carabid populations does not deviate from a log-normal distribution (expected if fluctuations occur at random).
2. Carabid numbers fluctuate between positive bounds that are generally more widely separated than expected with random fluctuations.
3. As a corollary of 2: local carabid populations generally die out more frequently than expected.
4. The above conclusions are not restricted to carabid species occupying temporary habitats; they also apply -though less extremely so- to inhabitants of permanent habitats.

## 56.5. 2

### THE NUMBERS OF EGGS IN THE OVARIES OF CARABID BEETLES AS A MEASURE OF THE QUANTITIES OF FOOD IN THE FIELD.

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The average fecundity (measured as the number of eggs in the ovaries) of several fieldpopulations of Carabid beetles has been determined from 1963 till 1980. This population feature is highly variable both in time and space. Here special attention will be paid to the influence of food. In spite of the variability, a distinct and positive relationship exists between the numbers of eggs in the ovaries and the quantities of food taken. Consequently it will be demonstrated that the numbers of eggs in the ovaries (and even other characters as the size of the beetles) can be used as an estimate of the availability of food in the field. Finally the existence of a high fecundity at low densities and a low fecundity at high densities will be discussed in this context.

56.5.  
3

# ANT AND ANT BROOD PREYING LARVAE: AN ADPTATION OF CARABID BEETLES TO AN ARID ENVIRONMENT

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Previous examinations have shown that larval stages and especially eggs and pupae of Carabid beetles are extremely sensitive to low soil moisture. As a result carabids in seasonally arid habitats generally breed only during rainy seasons. The shorter the rainy season, the shorter is the period that allows survival of the developmental stages. Especially their normal environment, the upper soil layers, dries up quickly. A successful settlement of carabids in semidesert regions is obviously possible by special feeding behaviour of the larvae. They enter ant nests and prey on ants and antbrood. The gallery system of ant nests in these habitats extends down to deep soil layers, where the high moisture prevails for a comparatively long time. Therefore sufficient soil moisture in the upper layers is required only for the period of embryonal development. Preying on ants and antbrood was found in larvae of the following carabid species from arid habitats of Africa: *Graphipterus serrator* and three species of the genus *Thermophilum* (*Anthia*): *T. galla*, *T. sexmaculatum* and *T. venator*

## 56.5. LIFE CYCLE AND AGE IN CARABUS HENNINGI F-W.(COL.,CARABI- 4 DAE) IN THE SUBARCTIC OF THE SOUTHERN YAMAL.

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In the southern tundra of the Yamal peninsula *Carabus henningi* inhabits mainly the floodplain meadows and the outskirts of bush thickets penetrating into the tundra.The beetle is active beginning from the middle of June up the middle of August and reaches the maximum of numbers by the end of June-beginning of July.At this period population of *C.henningi* consists of five generations of the previous years.The new generations appears by the end of July and starts reproduction only from the next season.

Thus,one can refer the life cycle flexibility in the subarctic populations of *C.henningi* as an adaptation to the short vegetation period and low temperatures.As a result rather complicated age structure is formed in the beetle populations,largely determining high productivity of the species.

56.5.  
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EFFECT OF TEMPERATURE ON THE PROPAGATION RHYTHM OF THE  
DESERT CARABID BEETLE *THERMOPHILUM SEXMACULATUM*

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The desert carabid beetle, *Thermophilum sexmaculatum*, occurs in two different climatic regions: in the southern Sahara and Sahelian Zone with rain during the summer, and, on the other hand, in the northern Sahara with Mediterranean winter rain climate.

Beetles from the summer rain region mature in a wide temperature range without dormancy. In their natural habitat they may show only a weak propagation rhythm. Beetles from the winter rain region, however, show a distinct seasonal rhythm of gonad maturity. Reproduction takes place at the end of the rainy season. The reproduction rhythm is controlled by an endogenous rhythm synchronized by changes in temperature. Thermoregulation is supposed to be of great importance in controlling propagation rhythm. Immature beetles (young beetles and beetles during their refractory period) prefer significantly lower temperatures than maturing or mature animals. The latter are able to regulate body temperature by using radiant energy at the beginning of the reproductive period. Sunbasking only occurs in spring. Immature beetles mature immediately if transferred into the temperature conditions preferred by mature beetles and stay mature under these conditions.

56.5.  
6

THE PHENOLOGY OF GROUND BEETLE COMMUNITIES IN ENVIRONMENTS OF SOUTHERN  
EUROPE AND ITS ECOLOGICAL SIGNIFICANCE.

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The annual phenograms of epigeous activity of ground beetles have been described by pit-fall trapping in several habitat types of Southern Europe and of the Alps (about 50 stands).

The inclusive activity curve of a carabid community depends highly on the meteorological events of a year, but for each habitat type and/or group a characteristic phenological pattern can be recognized. The form of a phenogram reflects two main orders of factors: i) macroclimatic variables; ii) habitat variables, especially vegetation and soil, which influence microclimatic features.

The duration of activity finds its maximum (up to 12 months) in warm-temperate or mediterranean climates, cold climates (high altitudes) and continentality can reduce it up to 3 - 4 months.

Activity peaks reveal often the habitat type: a spring maximum has been found not only in riverside biotopes (as already shown by Larsson, 1939), but also in wet pastures, in some alpine prairies with clayey soil and in most *Vaccinio-Piceetea*-forests.

A summer maximum has been observed in temperate broad-leaved forests (*Querceto-Fagetea*) and in montane pastures, a further spring peak is found in cooler beech woods. In mediterranean forests the activity peak shifts to the autumn, and the same phenomenon has been observed in pastures, where the autumn activity becomes more and more important if we move from Central Europe to the mediterranean area.

56.5. LIFE HISTORY PHENOMENA IN A CARABUS AURONITENS DEME  
7 FROM THE WESTPHALIAN LOWLAND (CARABIDAE, COL.)

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*Carabus auronitens* F. exhibits two seasons of locomotory activity. In spring, from the beginning of April to the beginning of June, the beetles reproduce. Afterwards, they stay in dormancy until the reproductive season in the next year, living on stores of their fat body, which is very well developed at the end of the reproductive season. Larvae and pupae develop during summer. In the second season, lasting from the end of August to the beginning of October, only freshly emerged animals are active. Obviously, the patterns of locomotion differ in spring and autumn: the rate of recapture is much higher in autumn than in spring. From capture-recapture experiments with individually marked animals, the density of the active animals in spring and autumn, and their rate of mortality were calculated. By marking the developing oocytes with trypan-blue the rate of laid eggs could be estimated.

56.5. AGGREGATED SPATIAL DISTRIBUTIONS OF CARABIDAE IN PITFALL TRAPS  
8

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Catches of Harpalus rufipes, Pterostichus madidus and other Carabidae were significantly aggregated in pitfall traps. Aggregations were partly independent of individual trap positions, and varied on each trapping date. Laboratory and field experiments suggest that the beetles' defensive secretions may act as an attractant pheromone at low concentrations. A model is presented which simulates the effect that this aggregation may have on pitfall catches, and its significance in interpreting population data is discussed.



## 56.5. 9

### STRUCTURE OF CARABID POPULATIONS IN BIODYNAMIC AND CONVENTIONAL CABBAGE FIELDS

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Carabid beetle and their prey populations were monitored with pitfall trap and direct counting methods in two biodynamic and two conventional cabbage fields near Frankfurt, Federal Rep. of Germany.

Large carabids were 5-50 times more abundant in biodynamic than in conventional fields. Most medium sized and small carabids were almost equally abundant in both types of fields. In biodynamic fields Pterostichus melanarius (Ill.), Loricera pilicornis (Fabr.), Agonum dorsale (Pont.), and Trechus quadristriatus (Schr.) were the dominant species. In conventional fields T. quadristriatus was the only dominant species, representing 60% of all carabid individuals in the autumn cabbage. The species diversity was generally distinctly higher in biodynamic ( $e^H = 5.5-6.0$ ) than in conventional fields ( $e^H = 4.1-4.7$ ). The dominance similarity of carabid faunae was highest between the conventional fields (over 70%), whereas the biodynamic fields were quite unique.

The results show that in comparison with conventional fields, biodynamic fields can support a more abundant and a more diverse predatory beetle fauna, which then is capable of controlling pest populations more efficiently. Therefore fewer pest outbreaks are likely to occur in the biodynamic fields.

## 56.5. 10

### DYNAMICS OF CARABID POPULATIONS AND DEVELOPMENT OF FOREST HABITATS

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On the basis of material collected in different age of stands the occurrence of Carabidae is described. The hypothesis is advanced that the variation in the population size of the particular Carabidae species depend on the state of development of forest environments. The application of clear felling in stands with a low level of development may lead to elimination of some species and to an extension of the range of some species the population size of which shows wide and frequent variations.

## 56.5. THE STABILITY OF CARABID PREDATOR-PREY SYSTEMS AND THEIR 11 POTENTIAL ROLE IN BIOLOGICAL CONTROL

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Recent studies in Carabidae contribute to another view on their function in predator-prey systems. Biotic factors appear to play an important role in the density regulation of their populations and the role of their larvae, almost ignored in the past, has been stressed. A number of density-dependent mechanisms has been described by now. Larval cannibalism is common and depends on the availability of other prey species. Most carabids are polyphagous predators and a number of observations suggest that they concentrate on the most numerous prey species. We suppose that these features render predator-prey systems with a carabid as predator quite stable in comparison with other predator-prey systems. The potential role of Carabidae in biological control is discussed. It is concluded that they might be effective in the prevention of outbreaks.

## 56.5. MUTUAL PREDATION AND COEXISTENCE IN CARABIDAE 12

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The difference many Carabidae show in their period of reproduction and activity can partly explain their coexistence. We investigated cannibalism and mutual predation in the larvae of Pterostichus oblongopunctatus and Pterostichus nigrita. Larvae of Pterostichus nigrita were less successful predators if confronted with larvae of the same age of Pterostichus oblongopunctatus. A less successful species can survive if its reproductive period precedes that of the other species by a sufficiently long period of time.

56.5.  
13

## DENSITY REGULATION IN FIELD AND FORMULA

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Over the past decades, a score of population fluctuation models has been made. These models, however, seldom include parameters computed directly out of field data. A method is proposed to determine the values of such parameters from series of annual estimates of population density. These parameters indicate the influence of respectively density dependent and density independent processes on the fluctuations in animal numbers. Simulations are carried out with a discrete model using parameters computed out of year-catch series of Carabid beetles. The generated fluctuation patterns are quite similar to the analysed field data, indicating that parametersets obtained in this way can give an adequate characterisation of density fluctuations as observed in nature.

56.5.  
14

## Ecological differences in sympatric *Chrysocarabus* populations

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Sympatric populations of the closely related *Carabus* (*Chrysocarabus*) species *lineatus* and *splendens* are a proper model to study the competition exclusion principle as well as the situation of their hybrids.

Besides altitude the field distribution of these species depends on the structure of the vegetation. As Lab experiments on climatic factors and the reaction against light conditions show the main differences between *splendens* and *lineatus* are to be found in the diurnal activity. The interbred specimens have an intermediate behaviour.

56.5.  
15 ON THE TRENDS IN ABUNDANCE AND DISTRIBUTION OF TWO  
CARABIDS /COLEOPTERA: CARABIDAE/

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A regressive trend of distribution is observed during recent years in the case of *Carabus cancellatus* Illiger, 1798, which was known formerly as widely distributed and common in Europe. Now it is very scarce in Slovakia at least and occurs locally in extensively managed, undestroyed habitats free of chemical treatment. A very similar *C. ullrichi* Germar, 1824, is still less known than the former one, according to data published. But this one is met now far more often and is even numerous locally. It seems, the second species replaces that first one continuously in suitable habitats through central Europe. The key factor causing this trend is not simple, nor single probably and would be determined by carabidologists in near future.

56.5.  
16 DENSITY FLUCTUATIONS IN A FEW CARABID GUILDS

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Carabids were sampled in 3 forest habitats during 5-10 years, dependently on the habitat. Among them 9 species of *Carabus*, 1 *Cychrus* and 2 *Pterostichus* - all predatory, nocturnal, surface active and of relatively large body - were supposedly able to compete for food, and thus could form interacting units, called here in "guilds". The guilds found in the habitats differed in species composition and in the number of species: from 5 to 12. Common features of the species in each of the guilds were: distribution of population density indices, DI, skewed to the right; fluctuation amplitude of DI higher in less abundant species; changes of DI in time moderately correlated in most species; and the highest specific DI highly concordant in most species. Models based on various assumptions - positive interaction, negative interaction, or no interaction at all - were tried to find out which one meets best the common features of DI found in these guilds.

## **56.5.** NICHE DIFFERENTIATION AND COMMUNITY ORGANIZATION IN FOREST CARABID **17** BEETLES

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The niches of the adult carabid beetles in two forest communities were investigated in detail over four years. Four aspects were taken into account to define the niches : annual activity cycle, daily activity rhythm, spatial distribution of activity, and diet. For each of these, niche breadths and overlaps were calculated.

Annual activity cycle and diet are the two main characteristics responsible for niche differences among coexisting species. Their combination results in a remarkable final niche differentiation, and even to a complementarity between the dominant species. The carabid communities appear as organized sets, structured around the central niche of the most dominant species.

In agreement with the classical theory, competition is concluded to be the fundamental force leading to the organization of carabid communities. Several elements provide evidence for the importance of competition for food in this process within the communities studied.

## **56.5.** Geographical differences of circadian locomotor activity in **18** Carabus

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Universität Bremen, NW 2, Postfach 330 440, D-2800 Bremen 33

The ecological role of circadian rhythmicity can be indicated by differences in locomotor activity of populations of species occurring in a wide range of latitudes. European Carabus populations of different latitudes were tested regarding several parameters of locomotor behaviour such as amount and distribution of activity, period length. Some population show differences in the distribution of the activity in the field.

Lab experiments indicate deviating results in northern and southern populations in respect to stability of endogenous period length.

56.5. WINGLENGTH DETERMINATION IN RELATION TO DISPERSAL BY FLIGHT IN TWO WING  
19 DIMORPHIC SPECIES OF CALATHUS BONELLI (COLEOPTERA, CARABIDAE)

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9418 PD WIJSTER, The Netherlands

Wing dimorphism in Calathus erythroderus Gemminger & Harold and Calathus melanocephalus (L.) was found to be determined genetically with brachyptery simple dominant to macroptery. In C. melanocephalus the longwinged genotype can be modified by environmental factors as temperature and food supply, whereas in C. erythroderus winglength is independent of such factors. It is argued that the resulting differences in phenotypic plasticity of the long-winged genotype (none in C. erythroderus and a varying amount in C. melanocephalus) do contribute to temporal and spatial differences in dispersal abilities of the two species concerned. The adaptive significance of the two types of inheritance is discussed.

56.5. ALLOMETRY AND EVOLUTION OF HIND WING DEVELOPMENT IN MACROPTEROUS  
20 CARABID BEETLES.

DESENDER, K., J.-P. MAELFAIT & M. VANEECHOUTTE.  
Lab. Anim. Ecol. K.L. Ledeganckstraat 35 B-9000 GENT BELGIUM.

Biometric data were gathered on size and hind wing development from a large number of macropterous carabid beetles, sampled in different habitat types in Belgium. Reproductive state and flight muscle development were also checked. A sexual dimorphism is apparent in most species, the females being larger but possessing relative smaller wings.

The same allometric constraint seems also valid when comparing different species.

Results are discussed in the light of carabid evolutionary histories as proposed by ERWIN (1979), DEN BOER et al (1980) and BRANDMAYR et al (1981).

S6.6.  
1

## STABILITY OF TROPICAL INSECTS

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The information available on fluctuations in abundance of insect species in a tropical forest is improving and now concerns up to 10 years of data obtained with light-traps. This information gives strong support to an earlier contention that fluctuations in abundance of tropical insect species are very similar to those of their temperate counterparts. The hypothesis that tropical insect species should fluctuate less has to be rejected. The relation between between-year changes in abundance and the seasonality pattern will be explored and possible effects of environmental factors will be discussed.

S6.6.  
3

## ECOLOGY OF THE CICINDELID BEETLE PENTACOMIA EGREGIA IN THE AMAZONIAN INUNDATION FOREST.

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*Pentacomia egregia* shows ground - tree migrations corresponding the seasonal inundations in the inundation forest of the Amazon valley. It is an univoltine species with different sexual periods between males and females. During the inundation the species shows a scototactic orientation. Cultivating experiments with different temperatures verified, that migration and the riping process is controlled by the night temperature of 26°C during the inundation period.

56.6.  
4

BIOLOGICAL VARIATION IN *Anopheles darlingi*  
ROOT FROM THE AMAZON BASIN.

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A wide range of behavioural variation in *Anopheles darlingi* has been demonstrated in South America. In some areas a pronounced zoophilic, exo-phagic tendency exists whereas in others the mosquito is primarily anthropophilic and endo-phagic. A high degree of chromosomal polymorphism has been found in larvae and evidence is presented that female wing size may vary in different populations. The possibility that this widely distributed species may be a species-complex could have important consequences for future malaria control schemes.

6

6.6. NEOTROPICAL SANDBLIES (DIPTERA:PSYCHODIDAE) AS VECTORS  
5 OF FLAGELLATES IN THE AMAZONIAN REGION, BRAZIL.

L. RYAN, R. LAINSON & J. J. SHAW.

THE WELLCOME PARASITOLOGY UNIT, CP 3, BELÉM, 66,000, PARÁ, BRAZIL.

THREE CONTRASTING AREAS WITHIN THE AMAZONIAN REGION ARE STUDIED IN TERMS OF THEIR PHLEBOTOMINE FAUNA AND THE ROLE THEY PLAY AS VECTORS OF FLAGELLATES WITHIN THESE AREAS .

THE MAJOR DIFFICULTIES THAT BESET THE MEDICAL ENTOMOLOGIST STUDYING SANDBLIES ARE RAPID IDENTIFICATION AND THE AGE BIAS OF THE SAMPLE: SOLUTIONS TO THESE PROBLEMS ARE PRESENTED, USING EXTERNAL CHARACTER KEYS AND OVARIAN AGEING (RESPECTIVELY).



56.6. SEASONALITY AND ITS ENVIRONMENTAL CONTROL IN  
6 TROPICAL GROUND BEETLES (COL., CARABIDAE)

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Pitfall catches in different tropical habitats (mountain forest, cultivated areas, riparian habitats) demonstrated a considerable seasonal change in the number of active beetles. In periodically dry habitats most beetles were active in the first months of the rainy season. This period is identical with time of reproduction. In riverside habitats many species reproduce mainly during the period of low water-level; however, few species behave contrary. We found univoltine species as well as species with only a slightly pronounced periodicity of reproduction. Carabid species without an annual reproduction rhythm are very seldom. The propagation rhythms are controlled mainly by changes of soil temperature, often in a very complicated way: changes of average temperature connected with the change of the daily amplitude of temperature. We have hints, that in riparian habitats also the change of salinity can influence the propagation.

56.6. On the natural history and ecology of small terrestrial ground-beetles  
7 (Col.:Tachyina:Polyderis) from an Amazonian black-water inundation forest.

ADIS, J., PAARMANN, W. & ERWIN, T. L.

INPA / Max-Planck - Convênio, c.p. 478, 69000 Manaus/AM, Brazil

Polyderis spp. represent one third of the carabid fauna collected in an Amazonian black-water inundation forest. P. nympa reproduces during the non-inundation period, lasting 5-6 months. Microclimatic changes, occurring by virtue of the rainy season, trigger emigration of immature P. nympa from the humus layer. Imagines fly to adjacent dryland forest where they attain maturity. With the receding flood, mature imagines recolonize the drying floor of the inundation forest. Reproduction takes place mainly during the following four months. The 'egg-imago' time-span is about 6-8 weeks. Three times more females hatch than males, assuring the existence of this species in the face of possibly severe losses during the inundation period. The univoltine development of P. nympa is considered to be an adaptation to the periodic loss of its terrestrial habitat.

56.6. SEASONAL DISTRIBUTION OF NECROPHAGOUS SCARABAEINAE  
8 (COLEOPTERA, SCARABAEIDAE) IN A COFFEE PLANTATION.

MIGUEL ANGEL MORON

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By means of a new bait trap (NTP-80) the necrophagous scarab beetles of a coffee-cacao plantation located at 430 m of altitude, near Cacaohatan, Chiapas, Mexico, were sampled during one year period. One plastic trap semiburied in the soil, baited with squid flesh and a preservation solution was replaced every y two weeks, obtaining 24 samples that comprise more than 1500 specimens belonging to ten neotropical species of Coprophanaeus, Phanaeus, Dichotomius, Canthon, Deltotichilum and Onthophagus.

The nocturnal species: Coprophanaeus telamon Har. and Phanaeus endymion Har. were dominant during Spring and Summer. Onthophagus rhinolophus Har. was the most abundant species during Autumm and Winter.

Nevertheless, as the temperature remains constant around the year (25°C) and precipitation has a monthly mean over 100 mm from Spring to Autumm, the majority of species are recorded during all seasons. The humidity, shadow and temperature at the floor of these plantations resembles tropical rain forest conditions and allows the activity of great part of the copro-necrophagous and sapro-carpophagous scarab beetles originally evolved in these areas.

6

56.6. AN ETHNOENTOMOLOGICAL SURVEY OF AMAZONIAN INDIANS  
9

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Indigenous peoples of Amazônia have adapted for millenia to insects as important factors in their ecological systems. This paper surveys the role of insects as food, crop pests, medicinals, influences in house types and seasonal human movement, and importance in myth and folklore. Special emphasis is given to indians as folk ethologists, particularly in the study of stingless bees (Meliponinae). Social insects are discussed as "Natural Models" for the Kayapó Indians, who symbolically recognize ny/nhy (wasps, bees, ants, and termites) in both myth and ceremony. Concluding comments suggest that ethnoentomology can not only offer social insights into indigenous cultures, but can also provide science with new data and testable hypotheses.

**P6.-** MICROCALORIMETRY AS A TOOL IN ECOLOGICAL ENERGETICS  
**1**

G.J. PEAKIN

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Goldsmiths' College

Estimation of the costs of maintenance (R) is conventionally made by measuring respiration, followed by conversion to units of energy. The conversion factor is based on often minimal knowledge of the nature of the respiratory substrate. Errors of as much as 25% may result (Southwood, 1966). These disadvantages can be circumvented by use of direct calorimetry. Its application to the measurement of R in terrestrial arthropods will be demonstrated.

**P6.-** REPOPULATION AND SUCCESSION ON NEWLY FORMED SLOPES IN  
**2** THE VINE YARDS OF THE KAISERSTUHL

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For 25 years drastic changes are imposed on the vine yards of the Kaiserstuhl. Small terraces are replaced by large terraces of several hectares separated from each other by steep slopes of 8 to 30 m heights, 45° inclination and several hundred meters of lengths. These newly formed slopes are surrounded by intensively used agricultural areas and thus provide an excellent experiment. Plants as well as animals have the opportunity to repopulate empty spaces. Repopulation and succession of zoophagous, detritophagous and phytophagous organisms and their different behaviour in the course of succession are described and compared.

P6.-  
3 FORAGING BEHAVIOUR OF CABBAGE ROOT FLY PARASITIDS.

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Aspects of the foraging behaviour of Trybliographa rapae Westw. (Hymenoptera:Cynipoidea) and Aleochara bilineata Gyll. (Coleoptera: Staphylinidae) are investigated. Laboratory and field observations are compared and used to determine the importance of density dependent factors for each species. The occurrence of multiparasitism by both species is also studied.

6

P6.-  
4 TO THE FAUNA AND ECOLOGY OF THE LADY BEETLES (COLEOPTERA, COCCINELLIDAE) FROM THE FAR EAST OF THE USSR

Kuznetsov V. N.

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The fauna of the Coccinellidae of the Far East of the USSR includes 80 species of 33 genera. Depending on the peculiarities of nutrition 4 species( *Henosepilachna vigintioctomaculata* , *Epilachna chinensis* , *Cynegetis impunctata* , *Subcoccinella vigintiquatuorpunctata* )are phytophagous, *Thea vigintiduopunctata* - mycetophagous, the rest 75 species are predators eating aphids , mealybugs, armored scales, psyllids, leat beetles larvae, spider mites. In Primorye and Priamurye the beetles of *Aiolocaria mirabilis*, *Harmonia axyridis*, *Synharmonia conglobata* form mass gathering in the places of their hibernation on rocks.

**P6.-** LIFE HISTORY OF COCCINELLA SEPTEMPUNCTATA BRUCKII  
**5** MULSANT IN JAPAN

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2. Biol. Lab., Kurume Univ., Kurume 830, Japan

Coccinella septempunctata bruckii is an important predator of aphids in Japan. We studied its life history in the field and the laboratory. As the peaks of adult emergence were observed in mid spring and early autumn, and occasionally in late autumn, it may have two or three generations per year. 1st-generation adults in the low land aestivated in loose aggregation in the base of weeds, while those in mountains were active. 2nd- or 3rd-generation adults overwintered in the grass, which fed aphids on warm days. Such an occurrence pattern of this species coincided with that of aphid populations. The annual life cycle of this species was sustained by the experimental results that its threshold temperature and the thermal constant were 11.1°C and 402.0 day-degree, respectively and the diapause-inducing condition for adults was the photoperiod of 14L10D at 18°C during larval stage.

**P6.-** POPULATION PERSISTENCE IN A DYNAMIC EQUILIBRIUM IN RELATION TO AVAILA-  
**6** BLE FOOD RESOURCE: A HERBIVOROUS LADY BEETLE, HENOSEPILOACHNA NIPONICA

TAKAYUKI OHGUSHI

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Population studies of a thistle-feeding lady beetle, Henosepilachna niponica (Lewis), were conducted from 1976 to 1980 at two different study sites to examine whether the local populations exist in a dynamic equilibrium state in terms of available food resource.

Food resource abundance measured as a number of thistle shoots on the two nearby study sites changed quite independently, but the egg populations surprisingly tracked the year-to-year changes in available food supply throughout the study course within each habitat. The average egg density with respect to food resource abundance over the five years was almost identical between the two local populations. After detectable external perturbations, mainly large-scale floods and arthropod predation, the egg populations quickly returned to a previous fixed level of density.

It is concluded that the local populations of the lady beetle persist in a dynamic equilibrium in relation to available food resource. The causal basis responsible for tightly resource tracking at the population level (population regulation with respect to available food resource) will be discussed.

P6.-  
7 SEASONAL SYNCHRONIZATION OF THE LIFE-CYCLE OF PTEROSTICHUS  
OBLONGOPUNCTATUS (COL., CARABIDAE)

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Larvae of the spring breeding carabid beetle *Pterostichus oblongopunctatus* pupate in summer. The young beetles emerge during late summer and autumn and go into diapause almost immediately. Synchronization was found to occur during pre-adult development. Larvae kept during long-day conditions developed much slower than larvae kept during short-day conditions. This difference was mainly due to a longer duration of the third larval instar. By means of this mechanism larval development is synchronized with the summer season and hibernation is restricted to the adult stage of life. The found mechanism has not been described in spring breeding carabids before.

P6.-  
8 DENSITY REGULATION IN NATURAL CARABID POPULATIONS BY  
LARVAL CANNIBALISM.

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The Netherlands.

The results of experiments in the laboratory suggest that larval cannibalism plays an important role in the regulation of the density of natural populations of Pterostichus oblongopunctatus. A simulation model was constructed which describes the course of the density of the developmental stages over the year. Parameters were estimated from laboratory and field experiments and resulted in a stable model population. The results of the simulations were verified in field experiments. The simulated larval and adult densities were in agreement with the observations.

P6.-  
9

SIZE, WING POLYMORPHISM, FLIGHT MUSCLE DEVELOPMENT AND LIFE CYCLE  
OF *POGONUS CHALCEUS* (COLEOPTERA, CARABIDAE).

DESENDER, K., J.-P. MAELFAIT & M. VANEECHOUTTE.

Lab. Anim. Ecol. K.L. Ledeganckstraat 35 B-9000 GENT BELGIUM.

Samples of the halobiont beetle *Pogonus chalceus* were gathered along the Belgian coast from three isolated sites differing according to their history and area.

Moreover, at one site with very high abundances, large samples were taken at approximately monthly intervals.

From these data the life cycle can be deduced.

Wing polymorphism and flight muscle development can be interpreted on the basis of the history of the different sites.

As to the size of the beetles, males are in any case smaller as compared to females, whereas a population living in a suboptimal edge site shows much smaller beetles than usual.

P6.-  
10

BIOLOGICAL AND ECOLOGICAL SIGNIFICANCE OF THE SEASONAL DISTRIBUTION  
OF *PTEROSTICHUS OBLONGOPUNCTATUS* (FABRICIUS) (COLEOPTERA, CARABIDAE)

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The results of ecological field investigations (e.g. by means of pitfall-trapping) are different distributions. These distributions are correlated to the abundance and activity of the individuals of a given population. Those distributions allow only an indirect and limited explanation of the structure and dynamics of the population. The aim of our investigation is, to establish a connection between biological significant phenomena and the discovered distribution. As biologically important parameters we considered the activity, state of nutrition, readiness for reproduction and duration of reproduction of individual marked specimen of the population.

P6.-  
11

CARABID POPULATIONS IN ALTITUDINAL GRADIENT:  
LIFE-HISTORY TRAITS AND STABILITY

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Distribution range of an insect species is often widely extended along altitudinal or latitudinal gradient. Local populations of such a species face different environmental stress and usually have acquired different life-history traits. Of these traits, diapause and dispersal strategies are quite universal and have been fully discussed in relation to adaptation to local habitats. But, variations in the patterns of population persistence and stability along such environmental gradients have not been well studied yet.

The carabid beetle, Leptocarabus kumagaii K. et K. is a monomorphic brachypterous ground beetle and a typical autumn breeder, which is distributed in Kinki, Japan, from low land to mountain top higher than 1000m. Local populations at altitudes of about 60m, 200m, 400m, 600m, 800m and 1000m were sampled by pitfall traps from May to November, and local population characteristics such as phenology, age structure, density and morphology were compared among the populations. The patterns of population persistence and stability in relation to climatic conditions and life-history traits are discussed.

P6.-  
12 THE REGULATION OF CLUTCH SIZE IN RELATION TO THE AVAILABILITY OF  
FOOD RESOURCES IN SILPHIDS

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The species of *Necrophorus* (burying beetles) bury small vertebrates and use them as food for their young during the larval stage. After having found a carcass a beetle (male or female) runs around it, creeps under it and lifts it. Some authors interpret this behaviour as testing the suitability of the carcass for breeding; if it does not prove suitable, the beetle will leave the carcass. Our investigation demonstrates that a female determines the abundance of food and regulates the number of eggs in relation to this abundance. Important parameters are size and weight of the carcass.



P6.-  
13

PHYTOPHAGAN POPULATION DYNAMICS ON PERENNIAL  
GRASS FIELDS

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It has been established that the phytophagan density maximum falls on May and July, with the summer maximum being predominant. The general trend of the seasonal activity is markedly affected by the development of the species with an autumnal reproduction type, their quantity being the same on the fields of different years of usage. Comparisons of the relative abundance dynamics of insect groups on perennial grasses of different years of usage have revealed considerable differences between Chrysomelidae, Curculionidae, all the phytophagan and one Chrysomelidae species (*Phyllotreta nemorum*). In contrast, no differences in the relative abundance dynamics have been found between *Phyllotreta undulata*, *Chaetocnema hortensis*, *Psylliodes cucullata*, *Sitona flavescens*, *Trachyploeus bifoveolatus*.

P6.-  
14

INTERRELATIONSHIPS AMONG BIOCLIMATIC FACTORS AND LIFE CYCLES ON  
H. POSTICA. (COLEOPTERA: CURCULIONIDAE)

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The alfalfa weevil, *Hypera postica* (Gyllenhal), is at present one of the most important pests on alfalfa (*Medicago sativa* L.) fields. The species is nowadays distributed throughout most of the Holarctic region.

Its great ecological plasticity allowed him to colonize places with so different a climate as the arid Middle East and the humid plus cold areas of Canada. This, of course, implies great difficulties when studying the life cycle of the weevil, which changes from place to place.

Information on the life cycle's response to changing environments can be obtained by reviewing data on the biology of the species from each locality it has been studied. This integration between biology and climatology permits us not only fix the determinant parameters of the life cycle's variability (number of generations, hibernation, etc.) but also to infer the possibilities of occupation of new areas.

P6.-  
15

CHANGES IN DUNG BEETLE COMMUNITIES IN THE SOUTH OF FRANCE AS A  
RESULT OF ENVIRONMENTAL ADAPTATIONS.

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Dung beetle have to cope with diverse selective pressures from their environment. From a known faunistic pool, species are sorted out according to predominant ecological factors and they combine inside each community so that they completely saturate the environment and exploit it to their maximum advantage. On a larger scale (region), mesoclimatic and geomorphologic factors govern the distribution of species but compensations between these factors occur in coastal areas. On a smaller scale (in sites) the structure of vegetation is the predominant factor which controls moisture and solar radiation intensity near the ground. Dung beetle communities appear to contain open field species which rarely fly into undergrowth. Competition between species of the same guild leads to the apportionment of time between them according to a strict chronology. On the other hand, the occurrence of several guilds reduces interspecific competition, the result being a greater diversity of communities.

6

P6.-  
16

SEMELPARITY OR ITEROPARITY AMONG BARK BEETLES ?

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Several of the bark beetle species (Coleoptera:Scolytidae) that have been investigated show indications of iteroparity, i.e. of breeding more than once: Parent beetles reemerge after completing their first brood and have the ability to establish a second.

From an evolutionary point of view it seems reasonable that they would try to breed a second time if they have the possibility. However, since it is difficult to track beetles after reemergence, the importance of a second brood in the population dynamics of the various species is uncertain.

A simple model that describes when reemergence occurs and how it is correlated with when trees are attacked may indirectly give information on the effect of the second brood on the population. The model is derived with data from the spruce bark beetle *Ips typographus* (L.) .

P6.-  
17

LIFE HISTORY OF THE EARWIG, ANECHURA HARMANDI IN JAPAN, WITH  
SPECIAL REFERENCE TO THE NYMPHAL HABIT OF EATING THEIR MOTHER

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The life history of A.harmandi in central JAPAN is described. A.harmandi is a common species living in mountain valleys in JAPAN. In late October, the adult earwigs begin to mate, and then enter hibernation. On hibernation, each female with a male makes a nest usually beneath a stone on sandy soil of riverside. Thus they hibernate in pairs. During the period of hibernation, each female lays about 90 eggs in a batch, mainly from middle January to middle February. After oviposition, the female drives away the male from the nest. Female cares for her eggs until they hatch. Nymphs emerge in April. They eat their mother being alive about two days after hatching. After they eat up their mother, they disperse from the nest. 1st and 2nd instar nymphs stay mainly on the ground, and 3rd and 4th mainly on plants. Adults emerge from middle June to early July. Soon after emergence, each adult disperses from riverside. Thus only a few adults can be seen in summer. In October, they come back again to riverside.

In any other insects, the nymphal habit of eating their mother is not known. This habit has been known only in a spider Chiracanthium japonicum.

A.harmandi can lay only one batch of eggs. And the riverside of mountain valley in early spring is poor in foods for newly emerged earwig nymphs. Thus the habit of nymphs of eating their mother is regarded advantageous not only to nymphs but also to the mother in assuring her reproductive success.

P6.-  
18

Transition from Bi - to Monovoltinism in geographical populations of  
Panorpa vulgaris (Mecoptera)

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P. vulgaris is distributed in Europe from south to north. In the central part of the area (Southern Germany) the populations are bivoltine and display an eudiapause (in the sense of MÜLLER, 1966). The mode of development (diapause or non-diapause) is determined by an innate day-length threshold (SAUER 1977). In southern populations (48°N) the variation in day-length thresholds and critical number of days reflects the degree of correlation between day length and number of days and the critical point of time (SAUER 1977, 1980, 1983) in the past, when diapause must be initiated for survival. The distribution of day-length thresholds for example represents a sort of fitness curve for different genotypes which respond to distinct day-length thresholds. In southern populations each day-length threshold and critical number of days has its specific relative fitness. Both components of the signal factor, day-length threshold and critical number of days, are temperature dependent. In the northern part of the area (51°N to 56°N) the climatic conditions don't permit more than one generation. The variation in day-length thresholds in those populations is therefore non-adaptive. Here the variation reflects a cryptic photoperiodic responsiveness normally suppressed under natural conditions. How selection acts on the targets, day-length threshold, critical number of days and temperature dependence is demonstrated.

**P6.-**  
**19** FACTORS CONTROLLING THE LIFE CYCLE OF PIERIS BRASSICAE L.  
(LEPIDOPTERA: PIERIDAE)

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In southern Germany ( $48^{\circ}\text{N}/8^{\circ}\text{O}$ ) *P. brassicae* shows an obligate bivoltine life cycle. In most of the years a third generation will be produced with high fluctuating individual numbers. The question was: which individuals of the first and second generation take part of the third generation, and what is the controlling mechanism?

One factor of the controlling system is the innate daylength-threshold of each individual. If the threshold is exceeded by the natural daylength, a further generation will be produced. Whether the natural daylength exceeds or falls below the threshold during the critical phase of development, depends on a number of factors: 1) The unpredictability of emergence of the first butterfly generation in spring. 2) The population variability of the emergence. Late hatched butterflies of the first generation only produce one more generation. 3) The time of egg laying. Only individuals hatching from eggs which have been laid in the first couple of days after female emergence, have a chance to produce a third generation. 4) Each generation in a year lives under different and unpredictable climatic conditions. This leads to different durations of the larval development.

These facts taken into account, a life cycle table can be drawn up for *P. brassicae*.

**P6.-**  
**20** Inborn recognition of day length for aestivation in *Mamestra brassicae*

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*M. brassicae* has a wide range of distribution. Therefore, the geographically different populations are exposed to diverse climatic conditions. In the southern part of the range of *M. brassicae* periods of favourable environmental conditions are interrupted by drought periods in the summer and frost periods in the winter. With increasing latitude the drought periods become less pronounced and finally disappear; there periods of favourable environmental conditions are followed by frost periods only. The geographically different populations are adapted by special strategies to these particular conditions. Populations of Southwest Europe display hibernation and aestivation diapause. In contrast to a hibernation diapause (a real eudiapause in the sense of MÜLLER 1966) aestivation diapause is only a retarded pupal development. With increasing day length and temperature during the larval stage the fraction of aestivating pupae increases. We have shown by a large number of inbreeding experiments that each individual shows an innate day-length threshold for hibernation and aestivation. These day-length thresholds are different in the same individual, and vary geographically, as the temperature dependence of these thresholds does. Northern populations display a hibernation diapause only; but a very few individuals possess a cryptic ability to aestivate which is never expressed phenotypically under natural conditions.

P6.-  
21

# DIAPAUSE INDUCTION IN LOBESIA BOTRANA UNDER HIGH TEMPERATURES

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Lobesia botrana Schiffermueller (Lepidoptera, Tortricidae) is known to enter a facultative pupal diapause when the embryonic and larval stages are exposed to short photophases. Yet, in a laboratory stock originating from northern Greece and reared for years on an artificial larval diet, diapause occurred in part of the population also under a long photophase. Thus, when eggs were incubated at 30<sup>0</sup> in the dark and the larvae reared at a photophase of 16 h and 25<sup>0</sup> or 26<sup>0</sup>, but not 20<sup>0</sup>, 24-63% of the pupae entered diapause.

P6.-  
22

# THE INVASION OF MIGRANT MOTH TO JAPAN ARCHIPELAGO

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There are many species of the migrant moth in Japan. Most of them are regular visitors from Oriental Region and they repeat one to two generations at their arrival place, but finally become extinct before the beginning of the winter. Some other species, however, occasionally collected in Yakushima and northward, have not bred even a second generation. Therefore, in the present study, information of the latter cases was gathered as material for the study of the relationship between the migration of moths and air streams. 54 moth species (254 individuals) have been recorded in various parts of Japan with help of air streams caused by 151 cases of climatic conditions which are divided into six climatic patterns. Climatic patterns are as follows; a. Extratropical cyclone 47(31%); b. Typhoon 45(30%); c. Baiu front 35(23%); d. Akisame front 11(7%); e. Summer anticyclone 7(5%); f. Unidentified cases 5(4%). We may report and discuss the relationship between the departure place of moths and their arrival place in each climatic pattern, and our opinion on the mechanism of movement of moths with typhoon, and so on. This research was supported partly by a research grant from the Toyota Foundation (78-1-242; 79-1-148).

06.-  
23 COMPLEMENTARY LIFE CYCLES OF TWO EPHEMEROPTERAN SPECIES IN A BELGIAN  
CHALK STREAM ( EPHEMERELLIDAE, EPHEMERELLA).

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The two Ephemerella species (Ephemerellidae) of a chalk stream (Samson) in Belgium show typically complementary life cycles: E. major (KLAP.) (=Torlyea belgica LESTAGE) is a winter species with a very long growth period from August until following May and a short emergence period of about one month ( from mid-April to mid-June) whereas E. ignita PODA is a typical summer species with an eggs diapause during winter followed by a long hatching period begining in February and continues until June; its growth is very rapid and the emergence starts in July and ends in October. The first species has very synchronized hatching and emergence periods, contrary to the second one for which they are more dispersed. The density-fluctuations are also complementary: one of the species is abundant in the river while the other is very scarce. These two species avoid competition by complementary life cycles.

06.-  
24 DISTRIBUTION OF SOME POORLY KNOWN MAYFLY SPECIES IN SWITZERLAND.  
(EPHEMEROPTERA).

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All mayfly larvae (Ephemeroptera) are aquatic, therefore their distribution is related to the kind of streams or rivers in which they live. The imago flying capacities being rather limited, they are very closely associated to the water. Due to the swiss landscape consisting mainly of two mountainous ranges (Alps and Jura), numerous species found there are considered to be endemic. Data on some of them will be presented. They have the particularity to be poorly known because of taxonomical problems and of few specimens collected until this research. In fact, some of the studied species are quiet abundant. Limits of their distribution considered with the importance of biotic and abiotic factors, allow a better understanding of the biology of these species.

**P6.-** CONCORDANCE OF THE ECOLOGICAL REQUIREMENTS OF THE CHIRONOMIDS WITH EPHE-  
**25** MEROPTERA AND PLECOPTERA IN THE NORTHERN SPANISH RIVER ORIA\*.

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The Oria, a Northern Spanish river is of interest from a Biogeographical and Ecological point of view, one part is situated between the Cantabrian System and the Western Pyrenees, and the other part is situated in an area of great industrial development.

The Oria River bassin had been studied in the spring, summer and autumn in 1981 and in the winter 1982. According to Quironomids's discernment of classification of Wilson and McGill's 1982 in function to degree of toleration in the current waters: 1. The intolerant species (A category Thienemannimyia f.ex.) is founding in the places of study with great (8-10) Biotic Index of Woodiwiss B.I.W. 1964) preferably. 2. The facultatives species (B and C categ. Orthocladus (Orth.) f.ex.) is found in the places with B.I.W. 4-10. 3. The tolerant species (D categ. Prodiamesa f.ex.) is found in the places with B.I.W. 2 o more showing a maximum in the places with B.I.W. 5, owing to the species of Ch. thummi gr., which are in 12 of the 18 studied places. These categories of indicative species according with the ecological requirement of the Ephemeroptera and Plecoptera species, according to Woodiwiss's discernment (Herrera Mesa, L. 1983), therefore any one requirement can resolve the indicative species of water's quality.

\* Project of Dip. Prov. Guipúzcoa and E.T.S. Ing. Ind. San Sebastián.

\*\* With a fellowship of Alexander von Humboldt-Fundation (F.R. Germany)

**P6.-** INFLUENCE OF THREE ECOLOGICAL FACTORS IN THE PATTERNS OF DISTRIBUTION  
**26** IN PARAGUS LATR. AND CHRYSOTOXUM MEIG. SPECIES (DIPTERA, SYRPHIDAE).

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We study the influence of three ecological variables: The altitude, the vegetation and the opening grade in the geographical distribution of some species belonging to the genus Paragus and Chrysotoxum, the altitude being (for all species studied), the principal ecological factor that determines their distribution. In this way, the altitude interval is indicated where each species is generally found, also the type of vegetation and the opening grade most frequented by each of them.

The basis of the analysis method employed was a systematic sampling during an entire year (from April of 1980 to April of 1981).

The areas studied were the three westernmost mountain ranges of the Spanish Sistema Central: Béjar, Francia and Gata, with 79 sample points being located between 2.400 metres of maximum altitude in the Pico del Calvitero (Béjar) and 350 metres minimum altitude in El Torno, a site located in the valley of the Jerte river that marks the oriental limit of the study zone.

P6.-  
27

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Porphyrophora Hamelii, an endemic of the Ararat plain, is a producer of natural carmine. In recent years under anthropogenic pressure, the area of cochineals has been sharply reduced threatening the very existence of this valuable species.

On the basis of our investigations 200 hectares of salines have been allotted, for the first time in our republic, for the protection of this insect.

Another means of maintaining Porphyrophora Hamelii is the working out of methods for its rearing in artificial conditions. Work in this direction enabled us to obtain 2 to 4 times more biomasses of insects than in natural conditions.

F6.-  
1 A FIXED ACTION PATTERN AS A CONTROL MECHANISM AGAINST DESICCATION AND OVERHEATING IN A HYGROPHILOUS INSECT. (ORIGINAL TITLE: DIE HÖHLBEWEGUNG BEI ELAPHRUS CUPREUS).

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The diurnal and hygrophilous Carabid beetle *Elaphrus cupreus* lives on muddy banks of ponds. If threatened by desiccation and/or overheating it hides in the soil. Because digging is impossible in the wet soil of their habitat, the beetles enlarge available cavities with a special fixed action pattern: the body is lifted by extending alternately the hind legs and the legs of the left or right side and the elytra are pressed against walls and ceiling of the cavity.

The threshold for this behaviour is lowered by keeping the beetles on moist plaster which provides no cavities for the beetles to enter.

The action pattern then can be released either by touching the beetle's back or - as vacuum activity - by increasing the body temperature (through radiant heat) or by lowering the humidity.

These experiments indicate that increasing temperature and/or decreasing humidity force the beetle to seek cavities as an outlet for the performance of the fixed action pattern.

The film demonstrates this behaviour under natural and experimental conditions.

6





Section 7   **Genetics** .....

R 7.1.   *Population Genetics and General Genetics* .....

S 7.1.   *Genetics of Development* .....

P 7.   .....

F 7.   .....

## R7.1.

1

### ENZYME PATTERNS IN PARTHENOGENETIC INSECTS

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Parthenogenetic forms, often with differing degrees of polyploidy, may be widely sympatric with diploid bisexual forms of the same species. Bisexual insects have only occasionally identical enzyme phenotypes over many enzyme loci. In contrast, members of a parthenogenetic lineage are all alike. They may differ extensively from other lineages. As different lineages are, in a flagrant contradiction to certain ecological theories, widely sympatric, recognizing them from bisexual forms poses a practical difficulty. Parthenogenetic polyploids may have characteristic enzyme phenotypes, which helps recognizing them. Electrophoretic studies on parthenogenetic insects have shown that adaptation processes and historical factors can be traced in the distribution of these forms. Many parthenogenetic insects are pests (aphids, scolytids, curculionids etc) so that these studies have practical importance.

## R7.1.

2

### RELATIVE FITNESS OF FIVE SPECIES OF THE NASUTA SUBGROUP OF DROSOPHILA.

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Relative fitness is the average contribution which the carriers of a genotype, or an array of genotypes make to the gene pool of the following generation (Dobzhansky, 1968). The fitness of the competing species can be calculated by adopting the statistical procedure of Ayala (1969). The relative fitness has been estimated in morphologically almost identical and cytogenetically as well as phylogenetically closely related species namely, *D. nasuta nasuta*, *D. n.albomicana*, *D. pulaua*, *D. sulfurigaster neonasuta* and *D. s.bilimbata*. In spite of their 'biological nearness' the relative fitnesses of the species under experimentation differ significantly from one another. In view of these, the implications of species differentiation at ecogenetic level will be discussed.

**R7.1.** THE GENETICS OF *DACUS OLEAE*: CHANGES OF ALLELIC FREQUENCIES  
**3** FOLLOWING ARTIFICIAL REARING.

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Previous work has shown that under laboratory conditions electrophoretic variants of the Adh locus obtain different frequencies than those occurring in natural populations. The question arises if this response is unique to Adh locus or is shared by other polymorphic loci. For this reason, we have surveyed a natural population for several electrophoretically polymorphic enzymes and have, also, examined the laboratory colonies, one maintained on artificial diet for about 200 generations, the other for 30 generations. The natural population was scored before introduction in the laboratory, then a colony was established from the same population and was monitored in each successive generation; three generations were examined thus far. The following enzymes were scored: Adh, 6-PGD, G-6-PD, Idh, Hk, Lap, Pep, Pgm. The last six enzymes showed minor and non-systematic responses to laboratory conditions. On the contrary, rapid and consistent changes occurred at Adh and 6-PGD. Over three generations in the laboratory the fast (F) allele of Adh increased its frequency from 30% to 80%. This is the first observation on the behaviour of the F allele in the absence of the I allele. The latter was always present in the founder populations of our previous work. Over the same time the fast (F) allele of 6-PGD increased from 20% (its frequency in natural populations) to 65%. This allele has a high frequency (over 80%) in the 30-generations and 200-generations colonies. Thus, three generations of artificial rearing caused a dramatic change, in the allelic constitution of a population of *Dacus oleae*, in at least 25% of its genes.

**R7.1.** THE GENETICS OF HOST SELECTION IN RHAGOLETIS (DIPTERA:  
**4** TEPHRITIDAE)

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A knowledge of the genetic basis of differences in host selection behavior among closely related *Rhagoletis* host races and species is essential for an understanding of the evolution of these host specialists. A variety of behavioral assays were undertaken in order to precisely quantify differences in these ecologically important traits. These were combined with selection and hybridization experiments so that estimates can be obtained concerning the number of genes involved as well as the genetic correlation between host selection and other ecologically relevant traits such as survival ability. These results hold implications for models of sympatric speciation by host race formation.

**R7.1.**  
**5** PARENT DEPENDENT GENOTYPE-ENVIRONMENT INTERACTION FOR COCOON WEIGHT IN PHILOSAMIA RICINI HUTT.

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Nature of genotype-environment interactions were studied in 6 parents and in  $F_1$ ,  $F_2$ ,  $F_3$  and  $F_4$  generations of 6 crosses for cocoon weight of Philosamia ricini Hutt. A major portion of these interactions was accounted for by the linear function of the environmental means although a significant portion was independent of the linear components. The components  $d_i$ ,  $b_i$  and  $S^2_d$  in the segregating and non-segregating generations indicated that the difference in cocoon weight and in linear and non-linear environmental sensitivities among the 6 parents reflected in the properties of the advanced generations of the six crosses. A clear evidence of segregation for differences in linear sensitivity among  $F_3$  and  $F_4$  families of the crosses where parents differ in respect of linear sensitivity whereas little evidence of segregation is noted for difference in  $b_i$  among the  $F_3$  and  $F_4$  families where both the parents of the cross had either a 'high' or 'low' sensitivity to the environment. Moreover these segregation were symmetrical around a mean values that corresponds with the mean of the parents of the cross. No clear cut pattern of segregation was found for non-linear components as found for linear components.

**R7.1.**  
**6** EXPRESSION OF GENETIC AND BIOCHEMICAL TRAITS IN HYBRIDS OF TRIBOLIUM CASTANEUM AND T. FREEMANI (COLEOPTERA: TENEBRIONIDAE)

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Among the Coleoptera, Tribolium castaneum represents the best known species from the genetic standpoint: its genetic library consists of some 125 visible and a few biochemical mutants. Some mutants are sex-linked, while others are autosomal recessive, semidominant, or dominant with recessive lethal effects. About half of the mutants have been identified with their 10 possible linkage groups - Tribolium castaneum and T. freemani can produce abundant (sterile) hybrids. Hence, an opportunity has arisen to test whether biochemical or visible mutants discovered in T. castaneum have homologous counterparts in T. freemani. The results of genetic experiments and experiments utilizing the technique of electrophoresis will be reported.

**R7.1.**  
**7** VARIABILITY IN THE NUMBER OF CHROMOSOMES OF BEETLE GENERA  
PARTICULARLY THOSE OF CHRYSOMELIDS.  
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The variation in the diploid numbers within those beetle genera with at least eight checked species or chromosomal races has been analysed by using standard deviations. A particular emphasis is given to the chromosomal evolution of the Chrysomelidae, where there is a wide heterogeneity in the chromosome numbers and sex-determining systems. The possible factors involved in the extent of variation in the diploid numbers of beetle genera are also discussed. It seems that those conditions promoting sedentary behaviour such as flightless or weak flying capacity and narrow trophic or edaphic characteristics, are correlated with high heterogeneity of chromosome numbers. On the contrary, a good capacity for dispersal common to those species with a powerful flying potential, and/or polyphagous habits are generally associated to slight or even null variation in number of chromosomes. Finally, the interrelationships between the chromosomal numeric variability and the speciation in Coleoptera are also briefly summarized.

**R7.1.**  
**8** SILVER STAINING OF THE SEX PARACHUTES ( $Xy_p$ ,  $X_p^{neo}X^{neo}Y_p$ ) OF SOME  
POLYPHAGAN BEETLES

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In the  $Xy_p$ , the most common sex bivalent of male Coleopterans, the association is supposed to be nucleolar. This has been recently questioned, because silver staining methods do not reveal any NOR in  $Xy_p$ . We also failed to show it in Diaprepes, Exophthalmus, Compsus, and Menoetius spp. (Curculionidae), although we obtained a heavy general marking, varying from a total staining of  $Xy_p$  to such cases where borders of the "lumen" adjacent to the sex chromosomes<sup>p</sup> were marked. This result could mean that the sex chromosomes have no localized NOR, but produce nucleolus, or some other  $AgNO_3$ -reducing substance, diffusely. On the other hand, the  $X_p$  of a translocation derivative,  $X^{neo}X^{neo}Y_p$ , is persistently argentophilous in an Elaterid, Pyrophorus luminosus Ill., whereas the "lumen" material remains always unmarked. Presence of a non-nucleolar "segregation body substance" in the parachutes seems feasible.

**R7.1.** GENETIC AND HYBRIDIZATION ANALYSIS OF THE RELATIONSHIPS AMONG  
**9** SUBSPECIES OF THE TSETSE GLOSSINA MORSITANS (DIPTERA: GLOSSINIDAE)

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Polyacrylamide gel electrophoresis was used to determine the allele frequencies at 12 loci in two colonies of Glossina morsitans morsitans Westwood, two colonies of G. m. submorsitans Newstead and one colony of G. m. centralis Machado. Each colony originated from a different geographic region. Intra-taxon similarities are significantly greater than are inter-taxon similarities. The latter demonstrate that G. m. morsitans and G. m. centralis are more closely related to each other than either is to G. m. submorsitans. Hybridization experiments confirm this relationship and suggest that G. m. centralis occupies a position intermediate between the other subspecies since its males have the greatest capacity to fertilize females from the other taxa. Marker genes on each of the three linkage groups are being used to establish the genetic basis of sterility among  $F_2$  hybrid males and to determine the extend of genetical recombination in hybrid females.

**R7.1.** GENETICS OF MALARIA VECTORS OF INDIA  
**10**

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The application of genetic techniques in defining the biological races of malaria vectors is a recent development in India. Studies have revealed that A.culicifacies is the most important vector of malaria in large parts of the country. The vector has been extensively incriminated, and consists of atleast 4 sibling species. The distribution and role of these sibling species is being worked out to evolve a realistic strategy of malaria control at reduced operational cost. Similar studies are in progress with A.stephensi, the vector of urban malaria. These developments would be discussed highlighting the role of genetics in understanding the epidemiology of malaria in order to develop realistic methods of vector control.

**R7.1.** INDUCTION OF DOMINANT LETHALS BY TWO CARBAMATE FUNGICIDES  
**11** - DITHANE M-45 AND BENLATE IN BOMBYX MORI.

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Dithane M-45 (Zinc ion manganese ethylene bisdithiocarbamate) and Benlate [Methyl-1-N-(1-butyl carbamyl) 2-benzimidazole] are two widely used fungicides to eradicate fungal infections in agriculture and moriculture. The stress has been laid on the utilization of the silk worm, Bombyx mori for environmental toxicity and mutagenicity studies. In view of this, the two carbamate pesticides were analysed for their induction of dominant lethals in three polyvoltine races of the silk worm by pupal injection technique. Different concentrations were used. The higher concentrations (above 750 ppm) were found to be significantly effective in inducing dominant lethals in all the races tested. The possible genetic effects of the fungicides are discussed.

7

**S7.1.** REGULATION OF EXPRESSION OF THE GENES CODING FOR THE DROSOPHILA YOLK  
**1** PROTEINS

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The genes coding for the yolk-proteins (YPs) of Drosophila melanogaster are transcribed in the ovaries and fat bodies of adult females but are not transcribed in adult males. This sex-specificity seems to be under the control of the sex-determining genes tra, tra-2, ix and dsx. Males can be induced to transcribe their YP-genes by high doses of 20-hydroxyecdysone. Using cloned YP - DNA probes we have found that YP-gene transcription in males after hormone induction is transient and the YP - RNA is rapidly degraded. Similar hormone treatments can induce increased YP-gene transcription in females. In both males and females the response to the hormone is tissue-specific, being limited to the body walls. By labelling RNA in vivo we have shown that in females the YP-genes are being continuously transcribed. We can detect no differences in 20-hydroxyecdysone levels in adult males and females which might account for the normal sex difference in YP-gene transcription.



## **S7.1.** TOTAL RNA AND mRNA SYNTHESIS IN DIFFERENT CELL TYPES OF THE **2** OVARY OF THE FLESHFLY, *SARCOPHAGA BULLATA*

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Using autoradiographic and histochemical methods, we have demonstrated that the nuclei of the nurse and follicle cells of the ovary of *Sarcophaga bullata* synthesize large amounts of RNA. These cell types show a high degree of polyploidy. The germinal vesicle is not actively involved in RNA synthesis although oocyte and trophocytes are genetically identical. In the germinal vesicle chromatin is condensed to a heterochromatic karyosphere. This condensation may be responsible for the almost undetectable rate of RNA synthesis. Time dependent autoradiography revealed that the RNA is transported from the nurse cells to the oocyte. The distribution and localisation of poly(A)<sup>+</sup> RNA in the nuclei of the different ovarian cell types has been investigated by "in situ" hybridisation using (<sup>3</sup>H) poly(U) as a homopolymer probe. "In vitro" translation experiments indicated that the ovary contains mRNA, coding for the three yolk polypeptides.

## **S7.1.** TEMPLATE ACTIVITIES OF RNA IN RELATION TO THE ONSET OF EGG DIAPAUSE **3** OF BOMBYX MORI

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Our previous studies have shown that the spectrum of translatable mRNA changes little during development after the break of diapause, although polysomes increase in amount during the same period.<sup>1)</sup> Here, we analyzed translation products of RNA extracted from newly deposited eggs before and shortly after the onset of diapause, by means of a rabbit reticulocyte cell free system followed by electrophoresis and fluorography. Results showed that the pattern of translates again exhibited little changes, indicating that there is no fluctuation of particular mRNA species in relation to the onset of diapause. Moreover, the patterns of translates of RNA from fertilized eggs resembled those of unfertilized eggs, suggesting that the distribution of embryonic mRNA is established during oogenesis.<sup>1)</sup> Saito, Koga & Sakaguchi, FEBS Lett., 150, 449 ('82).

**57.1.**  
**4** GENE ACTIVITY OF GERM CELLS IN DIFFERENT TYPES OF  
INSECT OVARIOLES

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Insect eggs contain maternal structural informations which seem to be RNA. These informations are stored in different parts of the cortical region. In meroistic ovarioles we have oocytes and nurse cells which are sister cells. In polytrophic meroistic ovarioles each growing oocyte is connected to its own set of sister cells, in telotrophic meroistic ovarioles all nurse cells are combined with all growing oocytes. Thus, if stage specific gene activity is needed to establish the maternal information in the egg cortex, it can be done in telotrophic ovarioles only by the oocyte genome itself, whereas in polytrophic ovarioles oocytes and nurse cells can contribute these informations as well. Data concerning stage specific gene activity of oocyte and nurse cell nuclei are presented.

**57.1.**  
**5** SEX PREDETERMINATION IN THE MONOGENIC BLOWFLY *CHRYSOMYA RUFIFACIES*

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The special mode of sex determination in the monogenic blowfly Chrysomya rufifacies is controlled by a dominant or epistatic female sex realizer ( $F'$ ) having sex predetermining properties ( $F'/f$  = female-producing female;  $f/f$  = male-producing female or male, respectively). To determine (1) the cell type in which the maternal effect gene  $F'$  is expressed, and (2) the autonomous or nonautonomous sexual differentiation of the germ cells germ-line mosaics were constructed in C. rufifacies by pole cell transplantations between both types of female embryos and between male and female ones. Results demonstrate that the  $F'$  gene product is synthesized by germ-line cells themselves, not by maternal (intra- or extraovarian) somatic cells; they show further that the sexual differentiation of a germ cell in C. rufifacies is not determined by its own genotypic constitution but is induced by the surrounding somatic cells.

**S7.1.**  
**6** NURSE CELL ANOMALIES IN THE MATERNAL EFFECT MUTANT DICEPHALIC OF  
DROSOPHILA MELANOGASTER

SANDER, K., LOHS-SCHARDIN, M., FREY, A., BOHRMANN, J. and GUTZEIT, H.O.  
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Homozygous dic females produce a low fraction of abnormal follicles. In these dic-follicles the oocyte is wedged in between two nurse cell (NC) clusters which arise by splitting of the normal complement of 15 NC; eggs from such follicles occasionally produce "double anterior" embryos. Analyzing the spatial arrangement of NC and connecting ring canals with the fluorescent phalloidin technique (R. Warn, pers. comm.) we encountered various anomalies, for instance NC severed from their sister cells, and oocytes with 2,3, or 5 ring canals. The disconnected NC would probably fail to empty their contents into the oocyte, as was frequently observed in films of late dic-follicles developing in vitro. NC clusters with reduced cell numbers approach the volume of normal 15 cell clusters and the DNA content of their nuclei is markedly raised. The bearing of these and other findings on current interpretations of follicle differentiation and of axial determination in the embryo will be discussed.

**S7.1.**  
**7** MOLECULAR ANALYSIS OF KRÜPPEL (Kr): A MUTANT INVOLVED IN SPATIAL  
PATTERN FORMATION OF DROSOPHILA MELANOGASTER

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A model system to follow molecular events involved in spatial pattern formation of the early Drosophila embryo is the embryonic lethal mutant Kr. In various alleles the segment pattern lacks the thoracic and up to five abdominal segments. The extreme phenotype develops only the last three (no. 6-8) and a duplicated (no. 6) abdominal segment which is reversed in polarity.

For a molecular analysis the Kr-locus was located by recombination and deficiency mapping at the tip of the second chromosome. This region was microdissected from polytene chromosomes and its DNA was cloned directly into  $\lambda$ -phage. The resulting clones were then used to saturate the Kr-region by overlapping recombinant DNA clones selected from a Drosophila library. The physical map of the Kr-region and its transcripts as well as their biological implications will be presented.

**S7.1.** MACROMOLECULAR CHANGES DURING OOGENESIS OF FORMICA POLYCTENA  
**8** FÖRSTER: A CASE OF TWO EGG TYPES DIFFERENTLY PREDISPOSED

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In caste determination of forest ants internal and external mechanisms are involved. After activation at spring-time the queens produce first w-eggs than s-eggs, w-eggs have a higher amount of RNA material than s-eggs. By phenolic extraction we could demonstrate an increase of the RNA content from 6 to 13 ug per ovary from the beginning of the activation period until the 2nd day, then the RNA synthesis caused by the nurse cells decreased to 6.3 ug until the first oviposition took place (normally after 8 days). In ovaries producing s-eggs only 4.4 ug RNA were present, this was the lowest content of RNA during the whole period of oviposition. The patterns of the isolated RNA fractions showed only quantitative differences between w- and s-egg producing ovaries. Also, the protein patterns demonstrated very few changes during oogenesis, the most significant result was an increase of the yolk proteins.

7

**S7.1.** GENETIC CONTROL OF BODY SEGMENTATION IN DROSOPHILA  
**9**

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The bithorax gene complex in Drosophila controls much of the differentiation of the larval and adult abdominal and thoracic segments. By manipulating the genes of this complex, flies can be produced with full transformation of halteres into wings, of wings into halteres, or of the first abdominal segment into a thoracic segment (8 legs instead of six) including frequent development of abdominal partially wing-like halteres. Similarly, profound embryonic transformations can be produced in which thoracic segments become abdominal, or abdominal segments thoracic. Another example is a mutant combination which invariably has 9 instead of 8 abdominal segments. These and other mutant effects will be illustrated. A model will be presented to explain how the genes become sequentially activated in anterior to posterior direction along the body axis.

**57.1.** MOLECULAR STRUCTURE AND SPATIAL PATTERNS OF EXPRESSION OF DROSOPHILA  
**10** HOMEOTIC GENES

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Homeotic genes are involved in the control of developmental pathways and the specification of body segments. Many of these loci have been genetically mapped in Drosophila, and a few have recently been cloned. We have found that three of these cloned genes, Antennapedia, Ultrabithorax, and fushi tarazu share a weakly cross-hybridizing DNA sequence. The sequence of the cross-hybridizing region shows it to be a conserved protein-coding domain. We have used the cross-homology to isolate other clones from a Drosophila genomic library. The cytogenetic map positions and spatial patterns of expression of genomic sequences homologous to two of the newly isolated clones suggest that they represent other homeotic genes. We propose that some of the homeotic genes of Drosophila are members of a highly diverged gene family.

**57.1.** EMBRYOGENESIS OF AN EMBRYONIC LETHAL, "KIDNEY-SHAPED EGG" IN BOMBYX  
**11** MORI, WITH SPECIAL REFERENCE TO MESODERM DIFFERENTIATION

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within the kidney-shaped egg, which laid by homozygous female, the embryo develops only ectodermal organs, but no internal organs. The early embryogenesis of this strain was examined with light and electron microscopy. Until the early germband stage no remarkable structural difference was distinguishable between the normal and kidney-shaped diapause egg, except the structure of rough-surfaced endoplasmic reticulum. Afterwards, the invagination of the primitive groove begins in the normal egg, on the other hand this process does not occur in the kidney-shaped egg and the embryo becomes slender gradually, accompanying with extrusion of several embryonic cells into the yolk system. This process was compared and discussed in both egg types.

**P7.-**  
**1** CHROMOSOMAL STUDIES ON THE EUROPEAN ALTICINAE (COLEOPTERA, CHRYSOMELIDAE).

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The chromosome number, sex-determining system, and the karyotype in a few cases, have been worked out on several species of European Alticinae belonging to eleven genera: Altica, Arrhenocoela, Hermaeophaga, Chaetocnema, Aphthona, Longitarsus, Phyllotreta, Psylliodes, Dibolia, Podagrica and Sphaeroderma. They have shown a large range of variation in all previous cytological features. The range of diploid numbers is from  $2n(\sigma)=17$  to  $2n=52$  chromosomes. Among the sex-determining systems have been recorded the following ones:  $Xy$ ,  $Xy_r$ ,  $X_1X_2Y$ ,  $Xy_p$  and  $X+y$ . The main aspects concerning chromosomal evolution of the European Alticinae are also discussed.

**P7.-**  
**2** CLONAL DIVERSITY IN THE PARTHENOGENETIC FLY  
LONCHOPTERA FURCATA.

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Investigations of parthenogenetic species have shown that clonal diversity is a common feature within or between populations. This study was made on multiclonal populations of the parthenogenetic fly Lonchoptera furcata at different sites in Scania, in the south of Sweden. The clones were identified on the basis of electromorph patterns and clonal diversity were calculated. Macroclimatological data, ecological heterogeneity, temporal dynamics and spatial trends were considered. It is suggested that the degree of clonal diversity is either density dependent or dependent on regular variation in clonal fitness, due to the temporal variation of habitat conditions.

### P7.- 3 GENETIC ANALYSIS OF THE ALFALFA WEEVIL COMPLEX FROM NORTH AMERICA

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Two species of alfalfa weevils are currently recognized. The alfalfa weevil, Hypera postica (Gyllenhal), is divided geographically into the western and eastern strains which were introduced in 1904 and 1951 respectively. The Egyptian alfalfa weevil, Hypera brunneipennis (Boheman), was introduced into southern Arizona in 1939. Although ecological and behavioral differences between these species and strains have been documented repeatedly, they are, however, morphologically indistinguishable. Our study seeks to clarify their genetic relationships. Field populations of these weevils were collected from their original habitats. Chromosomal analysis showed that all weevil populations have the same chromosome number of  $2N = 20 + XY$ . No differences in karyotypes and C-banding patterns were noted. Isozyme analysis of over 20 gene loci showed that the genetic distance between weevil populations was less than subspecies. Diagnostic loci were identified and allowed distinction between weevil populations. Both isozyme and hybridization experiments revealed that the eastern and Egyptian weevils are genetically closer than the western weevil. We conclude that all alfalfa weevils in North America are biotypes of the same species.

### P7.- 4 CONTROLLED ACCUMULATION OF VITELLIN IN BOMBYX EGGS.

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Vitellin accounted for about 40% on yolk proteins in the eggs developed in non-treated normal females of silkworms, whereas a trace level was found in the eggs developed in male hosts. Transplantation of female fat body into male hosts with transplanted ovary discs induced vitellin accumulation in the matured ovaries. Amounts of vitellin increased according to increasing amounts of implanted fat body and about 40mg fat body brought about vitellin accumulation of about 10%. Much higher accumulation (about 55%) was induced by the injection of ecdysterone into young female pupae. Further, vitellin amounts also dependent on strains of silkworms.

These results show that yolk protein composition in Bombyx eggs was controlled by the physiological conditions during oogenesis.

**P7.-** GEOGRAPHIC AND ECOLOGICAL PATTERNS OF CHROMOSOME POLYMORPHISM IN  
**5** DROSOPHILA MERCATORUM PARAREPLETA IN SOUTH AMERICA

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The karyotypic composition of 2364 males of Drosophila mercatorum pararepleta collected from different phytogeographic environments of South America was analysed. Seven widespread and four endemic chromosome inversions were found.

The central populations showed more variability than the marginal ones. Despite the fact that the marginal populations were geographically isolated from each other, they showed high genetic similarity. Although we cannot totally rule out the effect of natural selection as the main cause of some situations, there is no evidence that the geographic pattern could be caused by natural selection acting directly on chromosome arrangements. The low variability of the marginal populations could be the consequence of the fact that these populations are smaller. These populations are smaller probably because the ecological situations is adverse to the species, independently of the chromosome arrangements that they are holding.

The genetic similarity observed among the marginal populations is explained on the bases of the connection between them during the period of 13,000 to 18,000 years ago. The inversions found in the central populations are proposed as being new ones, which are now in the process of expanding. The small size of the marginal populations could be a barrier to this expansion.





Section 8 Developmental Biology .....  
R 8.1. *Compounds and Micro-Organisms Affecting Development* .....  
S 8.1. *Reproduction and Spermatology* .....  
S 8.2. *Oogenesis and Embryogenesis* .....  
S 8.3. *Gerontology of Insects* .....  
P 8.1.- .....  
P 8.3. ....

**R8.1.**  
**1** Effect of 5-bromodeoxyuridine on pupariation and adult differentiation in the fleshfly, Sarcophaga bullata.

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The thymidine analogue, 5-bromodeoxyuridine has a wide range of developmental effects. It was injected into mature larvae of the fleshfly, Sarcophaga bullata and its effects on pupariation and adult differentiation investigated. Pupariation was permanently blocked with 25 ug of the analogue per larva. The inhibition of pupariation could not be removed by injection, either of ecdysone, pupariation factors from normal prepupae or both. With regard to adult differentiation, BudR had no effect on imaginal disc differentiation. Even after 24 hours of BudR exposure, the imaginal eye discs, wing discs and leg discs from permanent larvae differentiated into normal looking organs upon transplantation onto normal prepupae. The results suggest that the thymidine analogue while effectively disturbing certain biochemical processes involved in pupariation, apparently has no effect on morphogenesis.

**R8.1.**  
**2** THE EFFECTS OF SUBLETHAL DOSES OF A BACTERIAL PREPARATION ON FECUNDITY AND GONAD DEVELOPMENT OF THE COLORADO BEETLE

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Sublethal doses of Bitoxibacillin (0.025 - 0.1% solution) based on *Bacillus thuringiensis* administered in food to larvae of the third and 4th instars induce pycnosis of individual germ cells, premature disintegration of cysts, development of a proliferation centre in testes and mutual invagination of previtellogenic follicles, hyperplasia of nuclei, vacuolation of ooplasm and disintegration of follicular epithelium in ovaries. The reproductive ability of males is not much reduced (mating with control females), but the adult longevity of females is shortened, oviposition is delayed, and fecundity is reduced to about half (fewer batches, fewer eggs per batch, irregular oviposition). Individuals of both sexes with major teratological defects do not multiply. Infection of adults with these doses does not substantially affect reproduction, concentrations over 0.5% prolong the praepupal stage of larvae up to 14 days.

R 8.1. "EFFECTS OF THREE BIOLOGICALLY-ACTIVE SUBSTANCES IN THE  
3 DIET ON THE DEVELOPMENT AND REPRODUCTION OF THE LEATHER  
BEETLE, DERMESTES MACULATUS DE GEER."

PROFESSOR R.A. BALOGUN AND G.E. OFUYA,  
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Nigeria.

The effects of three biologically-active substances namely, Sulfanilamide, Adrenaline and Beta Sitoserol in the diet on the development and reproduction of the leather beetle, Dermestes maculatus have been studied at 70% relative humidity and variable temperatures. Adrenaline and Beta Sitoserol each at 1.0% w/w, 0.5% w/w, 0.1% w/w, concentrations in the diet respectively produced loss in weight and an increase in larval developmental period. Sulfanilamide at 0.1% w/w concentration in the diet stimulated growth and reduced larval developmental period. The highest survival of larvae to the adult stage was found among larvae fed on fish meal containing Sulfanilamide while the highest mortality occurred in the fish meal containing Adrenaline and Beta Sitoserol; 1.0% w/w Sulfanilamide in the diet produced a significant increase in the proportion of males to females.

The possible implications of these results to control measures for the leather beetle were discussed.

R 8.1. THE EFFECT OF MICROORGANISMS ON REPRODUCTION IN CULEX PIPIENS AND THE  
4 Aedes SCUTELLARIS COMPLEX

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Individuals of most strains of the Culex pipiens and Aedes scutellaris complexes of mosquitoes are infected with bacteria which affect reproduction. Uninfected females when mated with infected males produce eggs which do not undergo embryogenesis although embryogenesis is normal in matings of infected with infected individuals, uninfected with uninfected individuals, or in matings of infected females with uninfected males. The consequence of this incompatibility is that when infected individuals are introduced into an uninfected population, infected females produce infected offspring but uninfected females produce offspring only if they mate with uninfected males; in this way uninfected individuals are rapidly eliminated from the population.

In the Culex pipiens complex, the bacteria have differentiated in different strains so that interstrain crosses frequently are partially or completely sterile.

It is hypothesized that the effect of the bacteria on the sperm of the infected male is such that the sperm is not recognized by an uninfected egg and is treated as a foreign body.

## 58.1. NEW FEATURES IN INSECT SPERM CYTOSKELETON

1

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The cytoskeleton of spermatozoa contains typically the tubulin-dynein system which is the main part of the axoneme. The two other systems (the microfilaments and the intermediate filaments) are by far less diffused. In insects the tubulin-dynein system shows interesting peculiarities in species having abnormal axoneme patterns, and mainly in sperm models devoid of tail and having different mechanisms of motility. The microfilaments system is represented around the centriolar region and in the acrosomal complex in the models conserving a perforatorium. The intermediate filaments system seems to be present only in the tail region, in Insects having crystalline extra assonemal accessory bodies, which are made up of ~10 nm filaments having MW and immunological characters of a keratin like protein.

58.1.  
2

## PAIRED SPERMATOZOA IN THERMOBIA (THYSANURA)

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Thermobia spermatozoa after a conventional spermiogenesis pair to form twin spermatozoa. This feature seems to be essential for sperm movement: free cells have a reduced motility or are immotile. The pairing is evident only in the anterior third of the spermatozoa which contains nucleus, axoneme and two mitochondrial derivatives as four parallel, longitudinal strands. The contact of the two spermatozoa is realized by the close proximity of the two plasma membranes which here form a kind of close junction. Freeze fracture replicas reveal at this level particle rows, one row on each spermatozoon; the rows of the two spermatozoa in a pair meet along the junction. In addition double rows of particles are evident on the mitochondrial derivatives presumably connecting these structures to the axoneme.

## 58.1. THE STRUCTURE OF THE NUCLEAR CALOTTES AND THEIR CHANGES 3 DURING SPERMIOGENESIS OF NOTONECTA GLAUCA

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In young spermatids the nucleus is surrounded by a layered shell of three to four fenestrated smooth cisternae in regular distance from the nuclear envelope. The nuclear envelope has pores all over in random distribution through which apparently dark material is transferred from the nucleus and gathered between the membrane layers. At the stage of the onion-shaped Nebenkern these membranes form local aggregations of anastomosing membranes which are in continuity with a great number of loosely arranged layers of cisternae towards the cell periphery. Contrary to the foregoing stage the nuclear envelope exhibits pores only at the calottes. In their fully developed form the peripheral cisternae show three local differentiations. Stacks of smooth membranes with irregularly wide openings continuously change into rough parallel membranes with narrow openings which themselves continue into sections without ribosomes where the two membranes of a cisterna are almost in contact with each other. At the periphery of a calotte small globular aggregations of dark material appear in the cytoplasm between the dilated ends of the cisternae. In some distance a greater aggregation of dark granular material is quite regularly observed in the cytoplasm. After division of the Nebenkern the calottes disappear from the nucleus. Conglomerations of parallel cisternae with the same arrangement of dark material as described before are found in the tail for some time longer. The nuclear envelope has still pores in those places where formerly the calottes have been attached. One single flat cisterna of endoplasmic reticulum covers this area. The nuclear calottes of Notonecta are unique. It will be discussed if comparable structures are found during spermiogenesis in other species of insects.

## 58.1. STRUCTURE AND MAKING OF SPERM BUNDLES (SPERMIOZEUGMA) 4 BY A CARABID BEETLE

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Mature carabid beetles form species-specific sperm bundles which are transferred into females during copulation. These spermiozeugma are made in a specialized part of the vas deferens of the testes containing numerous pocket-like structures. In *Pterostichus nigrita* a carrier rod is synthesized in each pocket. To this rod two opposite located rows of 20-40 sperms are attached. The bundled sperms can perform synchronuous movements. The structure of the spermiozeugma was investigated with TEM- and SEM-methods. In *Pterostichus nigrita* the formation of spermiozeugma is controlled by short-day photoperiods. Juvenile hormone can replace the photoperiodic stimulation.

**§8.1.** TICK COURTSHIP BEHAVIOR AND REPRODUCTIVE ISOLATION  
**5** OF SPECIES

SONENSHINE, DANIEL E.

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Highly stereotyped courtship patterns are used by many ticks and other arthropods to filter conspecific partners for mating, while deterring all others. Pheromones and allomones, alone or in combination with physical attributes and characteristic behavior of each species, mediate the discrete events in the mate finding process. No single courtship procedure applies to all ticks. Rather, several specialized mate finding strategies occur. In many ixodids, a single compound, 2,6-dichlorophenol, excites male detaching and searching behavior and facilitates orientation to the secreting females. In some species, males identify conspecific mates only at the final stages of mating, when probing the female gonopore prior to insemination. In other species identification occurs at the commencement of courtship behavior, and males detach only in response to a species - specific excitant pheromone. Species - specific aggregations also enhance conspecific mating. Differences in pheromone concentration and other unidentified repellants are also used to deter males from mating with females of other species. These few examples reflect a remarkable diversity in the evolution of courting behavior. An understanding of this principle, as well as knowledge of mating behavior of individual species, is essential to the development of any bio-rational tick control strategy in which pheromones are to be employed.

**§8.1.** THE AGGREGATION-ATTACHMENT PHEROMONE OF THE TROPICAL BONT  
**6** TICK *AMBLYOMMA VARIEGATUM* FABRICIUS (ACARI : IXODIDAE)

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Chemical analysis combined with bioassays revealed, that the aggregation-attachment pheromone produced by fed males of the tropical bont tick *Amblyomma variegatum* consists of o-nitrophenol, methyl salicylate and pelargonic acid in the approximate amounts of 2/1/8 µg /tick. A synthetic pheromone blend composed of those three volatile compounds evoked an aggregation response of unfed males and females in the bioassay comparable to the response to a natural pheromone source. Of the individual components, only o-nitrophenol induced a significant, although not complete aggregation response. Methyl salicylate and pelargonic acid contribute to complete pheromone activity, but induce no aggregation response at all, when offered separately. Together with a typical behaviour pattern of the fed males, this type of pheromone has a major impact on the meeting of the sexes on the host in this and close related species.

**58.1.** MEETING OF SEXES IN TICKS  
**7**

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COMPARISON OF PHEROMONE REGULATION OF BEHAVIOR IN ARGASID,  
PROSTRIATE AND METASTRIATE TICKS

8

**58.1.** DIFFERENCES IN COPULATORY BEHAVIOUR IN VARIOUS GROUPS OF TICKS  
**8**

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Copulatory behaviour is similar in all ticks; but there are differences in details between various groups. As a first step in copulation after reaching the venter of the female, the male probes the female gonopore with its mouth parts. In Argasidae, the male inserts all its mouth parts into the gonopore. In Ixodes, the male inserts only the chelicerae and the hypostome, while the palps remain outside the gonopore. In the Metastriata, the tips of all mouth parts including the palps touch the gonopore. Another difference relates to the transfer of the spermatophore (sp.) from the male gonopore to that of the female. In Argasidae, the male catches the sp. by the neck between its palps and applies the digits of the chelicerae to the tip of the neck. In Ixodidae, the male was never observed to use its mouth parts to remove the sp. from its gonopore; but it uses them to apply the tip of the sp. to the female gonopore while it is attached to the chelicerae by strands of filamentous material derived from dried saliva.



**58.1.** ADAPTATION OF INDIRECT SPERM TRANSFER TO EPEDAPHIC HABITATS IN MITES  
**9** (ACARINA, PROSTIGMATA)

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Indirect sperm transfer by arthropods in epedaphic habitats is generally affected by environmental conditions in two main respects:

- 1) The survival of the spermatophores is limited by fluctuations in atmospheric humidity,
- 2) Seeking a spermatophore or a mating partner is rendered difficult by an intricate habitat structure, which limits the range of signals.

Here we demonstrate that Prostigmata mites, which belong to the Anystae and Parasitengonae (Trombidiidae, Johnstonianidae, Calyptostomidae and Erythraeidae), are adapted to fluctuating relative humidity mainly through the ability of their spermatophores to maintain a stable water balance by taking up water vapour from unsaturated air. The most important adaptations to the intricate habitat structure are apparently signals deposited on the ground in the vicinity of spermatophores.

We discuss the fact that premating partner contacts existed originally within the Parasitengonae, but have been reduced convergently several times. Arguments are also presented about how dryness-adapted spermatophores and "long-term" signals are involved with the selection in favour of indirect sperm transfer without previous partner contact.

**58.1.** SPERM TRANSFER, STORAGE AND UTILIZATION IN *Dacus oleae* GIMEL.  
**10**

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**Abstract**

In *Dacus oleae* the spermathecae are transported free from male to female by direct injection of the semen into the vagina.

Sperm migration to the spermathecae takes place almost passively helped by the movement of the spermathecal duct and mainly by rhythmic contractions of the valve region muscles of the receptaculum seminis.

In order to investigate sperm behaviour during their movements and storage, chemiotactile attraction of the spermathecae by secretions from the spermathecal and annexed glands is also investigated through the fine structure and physiology of these glands, in new emerged, sexual-mature-vergin and mated females as well as during oviposition.

**S8.1.** ASPECTS OF THE CONTROL OF THE GONADOTROPHIC CYCLE IN THE  
**11** TICK *ORNITHODOROS MOUBATA* (IXODOIDEA, ARGASIDAE)

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The control of the gonotrophic cycle of *O. moubata* is dependent on both the blood-meal and copulation. The blood-meal triggers digestion and vitellogenesis. However, copulation is necessary to complete these 2 processes which lead to oviposition. If females are not mated, digestion is soon arrested and the developing eggs are resorbed. Mating of these engorged females permits the completion of the blood-meal digestion and oocyte maturation. Copulation provides 2 types of stimuli :

- 1) a mechanical one (stretching of the uterus) and
- 2) a chemical one represented at least by a protein contained in the spermiophore and which alone is able to trigger vitellogenesis in virgin females.

Recent findings on hormones present in the female are discussed in view of their possible interrelation in the scheme previously described.

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**S8.1.** PHYSIOLOGICAL CHANGES OF WILD OLIVE FRUIT FLIES REARED IN ARTIFICIAL  
**12** DIET AND IN OLIVE FRUIT.

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Wild olive fruit flies reared on artificial diet, under lab-conditions, undergo serious changes in their sexual and reproductive maturation, their mating frequency and distribution of matings, when compared to the same flies reared in olive fruit. Flies held for over two generations in artificial diet became sexually mature from the 3rd to the 5th day after emergence, while flies reared in olives matured from the 4th to the 20th day after emergence. Egg maturation occurred, in both populations, one to two days after sexual maturation. Males and females of artificially reared flies, mated more frequently than flies reared in olives. Experiments under different photoperiods, with the two populations (Lab-Wild), resulted in mating peaks differing 1 to 2 hours. Flies which had been reared for over 50 generations on artificial diet, then reared on ripe olives for three generations, showed that the above mentioned changes were irreversible.

## 58.1. SPERM MATURATION, CAPACITATION AND FERTILIZATION 13

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The descriptive processes of spermatogenesis, spermiogenesis, capacitation and fertilization are known to varying degrees in different arthropods. The morphological development of male germinal cells during spermatogenesis and spermiogenesis is well known in a variety of arthropods, but capacitation of sperm and details of sperm penetration of eggs (syngamy) are less well known. Moreover, the physiological control of all these processes is poorly understood, yet several reports suggest that the endocrine system is involved. Data will be presented on these topics using selected examples from different phylogenetic taxa including primates and various arthropods (Lepidoptera, Hemiptera, Orthoptera, Chilopoda, and Acari).

## 58.1. THE STRUCTURE, FUNCTION AND ENVIRONMENTAL ADAPTATION OF SPRINGTAIL 14 SPERMATOPHORES (COLLEMBOLA, ARTHROPLEONA)

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Our investigations on the spermatophores of *Orchesella cincta*, *Isotoma viridis* and *Isotomurus palustris* will be presented in this paper. Three points will be discussed.

1. the morphology, ultrastructure and histochemistry of the three main structural elements of the spermatophores: stalk, sperm droplet and sheath around the sperm droplet.
2. the mechanism of activation of the spermatozoa, which originally are spirally packed in the testis and in the spermatophore, and measurement of their lifetimes.
3. the water-balance of the spermatophores at different humidities and the role of the sheath in water uptake from the air.

The results indicate that the spermatophores are more complex than supposed so far. For example, the sheath is not a "condensating membrane", but is rather structurally differentiated and consists of a protein layer, secreted by glandular cells of the Ductus ejaculatorius.

58.2.  
1

A POLE CELL INDUCING FACTOR ISOLATED  
FROM DROSOPHILA EMBRYOS

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A periplasm in the posterior region of the Drosophila embryo is called polar plasm, and different from that in other regions in morphology and function. The polar plasm has been known to be able to induce pole cell formation when transplanted into an ectopic region of the periplasm. In the present study a subcellular fraction from the egg homogenate, and a polyadenylated RNA fraction extracted from the subcellular fraction were able to induce pole cells when injected into the posterior region of eggs that had been prevented from pole cell formation by uv irradiation at the posterior pole. The pole cells thus induced by injection of the polyadenylated RNA fraction in the uv-irradiated embryo exhibited EM and LM features almost identical to those of normal pole cells. However, these pole cells were found unable to differentiate into germ cells. The polyadenylated RNA fraction is either unable to form pole cells in an ectopic periplasm. The results suggest that there are more than one pole cell forming factors and one of the factors is a polyadenylated RNA, and that the germ cell determining factor is different from pole cell forming factors.

8

58.2.  
2 OOGENESIS AND VERY EARLY EMBRYOGENESIS IN THE TOBACCO  
HORNWORM, BIOCHEMICAL AND MACROMOLECULAR EVENTS (*Manduca sexta*).

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A stereotyped pattern of molecular events, similar to that described for sea urchins and amphibians has been observed in the Tobacco hornworm. Messenger RNA which was transcribed during oogenesis is not translated until after the egg is fertilized. Transcription of the embryo genome is not initiated until cellular blastoderm stages. This sequence of events suggests that these critical phenomena are under strict controls, and rely on "signals" within the fertilized egg for activation. We have examined aspects of such possible control mechanisms as modifications of the maternal messenger RNA, variations in respiration and intracellular pH, and sequestration of the components of the translational and transcriptional machinery. We have initiated a series of experiments to examine and assess these possible control mechanisms in determining the course of early embryonic development.

## 58.2.3 DEVELOPMENTAL FAILURE AFTER ARTIFICIAL ACTIVATION OF INSECT EGGS

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Oocytes from the oviducts of Venturia (Hym., Ichneumonidae) and from ovaries of the dipterans Smittia (Chironomidae) and Psychoda (Psychodidae) can be activated, with varying yields, by a brief exposure to distilled water or tap water. Complete embryogenesis was obtained only with oocytes from the parthenogenetic Smittia species and from mated Psychoda females while oocytes from unmated Psychoda females decayed after cleavage anomalies which might be due to genomic imbalance (implying that fertilization occurs in the ovary). In Venturia, cleavage mitoses are delayed and many nuclei lag behind in the yolk system while the others form an abnormal layer at the egg cell surface before degenerating. Venturia reproduces by parthenogenesis and moreover mechanical activation of its oocytes is followed by complete embryogenesis. We conclude that in this species osmotic shock, although initiating nuclear multiplication, suppresses or fails to trigger some indispensable reaction(s) in the ooplasm.

## 58.2.4 THE DEVELOPMENT OF ASYMMETRICAL "DOUBLE ABDOMEN" EMBRYOS IN MUTANT OR UV - IRRADIATED CHIRONOMUS EGGS (DIPTERA, CHIRONOMIDAE).

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The development of anterior segments in dipteran embryos is controlled by the activity of anterior cytoplasmic determinants. Inactivation of these components reprograms anterior blastoderm cells to form abdominal instead of cephalic or thoracic structures. Most of the resulting "double abdomen" embryos consist of a mirror image duplication of the last five to seven abdominal segments. However, some specimens are asymmetrical, juxtaposing structures that are widely separated in normal embryos. For instance, a terminal abdominal segment may be formed, with reversed polarity, next to a prothorax or to gnathocephalic structures. We have found a variety of such cases after anterior UV irradiation, and in an apparently mutant strain, spontaneous double abdomen (sda) of a Chironomus species.

We are currently analyzing the development of asymmetrical double abdomen embryos using LM, SEM, and TEM techniques. The objective is to determine whether cell death and regeneration, or abnormal morphogenetic movements, are involved, or whether the disparate but juxtaposed structures develop in situ. The latter case would be difficult to reconcile with models of pattern formation relying on diffusible morphogens.

## S8.2. DEVELOPMENT OF THE EMBRYONIC SEGMENT PATTERN IN INSECTS: 5 Morphological, Cellular and Molecular Aspects

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In the presence of a degenerated egg fragment, the complementary fragment of an insect egg appeared to have different options for development. A fraction of anterior and posterior fragments produced considerably more segments than corresponding fragments that cannot interact with a degenerated fragment. Another fraction, only of posterior fragments, produced double abdomens. These consist of a series of posterior segments joined in reverse sequence to an equal set from the original pattern persisting in normal sequence. Segment patterns appeared to change in an all-or-none fashion, depending on the stage of constriction. The alternatives for anterior fragments were: no excess segments or excess segments. The options for posterior fragments: no excess segments, excess segments or double abdomens. This difference in reaction between developing unipartite anterior and posterior fragments requires an asymmetric distribution of prerequisites for segment development in the egg. Reversal of segment sequence was often restricted to longitudinal stripes of the larval cuticle. If metamerization has to be accounted for in terms of diffusible morphogens, these strip-restricted reversals require the assumption of polarized morphogen transport. An electrical mechanism for such polarized transport is suggested. At the cellular level mitotic patterns in the egg did not foretell the pattern of segments. The induction of double abdomens with RNase and UV light suggests that RNA is involved in metamerization.

## S8.2. DEVELOPMENT AND MORPHOGENESIS IN THE COCKROACH 7

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Some of the morphogenetic mechanisms involved in the embryonic development of insects are also those governing the processes of appendage regeneration in larvae. It can be considered that the cells responsible for morphogenesis are planned to occupy a determined position in relation to one another. So, in order to understand morphogenesis, it is fundamental to know the cell position determination system. Graft experiments followed by regeneration and use of immunological techniques as topospecific monoclonal antibodies led us to demonstrate that i) the epidermal cells always tend to restore or recover normal neighbourhood contacts, ii) only the epidermal cells are involved in morphogenesis and iii) the material support of information implicated in cell recognition processes must be sought on plasma membranes. Each epidermal cell of an appendage does not seem to possess a particular character which individualizes it inside one set, but seems to belong to several sets whose intersections individualize each of them. Trying to reveal a particular character of a given cell is vain but it is possible to do so for a common character of a group of cells. It has been demonstrated that the femur cells have a common antigenicity corresponding to a material support of the "femur character" which is different from that of tibia. In the same way, groups of cells with a similar position along or around the appendage possess the same antigenicity e.g. segment base or segment apex.

Work on the characterization of the molecules involved in these processes is in progress.

## 58.2. PATTERN FORMATION OF THE SUPERNUMERARY REGENERATION OF LEGS IN THE BOMBYX SILKWORM

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Thoracic legs of the 3rd, 4th and 5th instar larvae of Bombyx mori were cut between 2nd and 3rd segments, and the separated tips were grafted back onto the stumps with or without rotation.

Homopleural grafting with 180° rotation and heteropleural grafting with 0° or 180° rotation produced 3 leg regenerates (orthodrome, antidrome and paradrome) at the adult stage. Direction of each leg regenerate followed the Bateson's rule, but arrangement of them were always dorsal to ventral. When the operation was performed on the 3rd instar larvae supernumerary regenerates of larval leg appeared at the 5th instar, and when that was done on the 4th or day 0 to day 2 of 5th instar larvae, two extra legs were produced in a high rate at the adult stage. Allatectomy on day 0 or day 1 of the 4th instar larvae prevents the formation of extra leg.

Clonal analysis of leg regenerates by the combination of two legs with different genetic markers could not specify the cell origin of each supernumerary regenerate.

## 58.2. COMPARATIVE RADIOSENSITIVITY OF MED-FLY CELLS AND EMBRYOS

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The research dealt with the effect of  $^{60}\text{Co}$  gamma radiation on cultured cells "in vitro" and on embryos at different developmental stages, of Ceratitis capitata Wiedemann.

The parameters chosen for both the cells and the embryos were growth, survival and mortality. The immediate and late effects of irradiation were also put into evidence on the egg hatching, the larval life cycle, the emergence of adults and their fertility.

A particular result that became evident in the comparison of the radiosensitivity was that the cells "in vitro" had a greater radioresistance than the very young embryos by a factor of 3.

In general, with an increase in dose there was an increase in damage; even at 1200 rad a prolonged arrest was found in the growth of the cell population, and with 2400 rad it was found in the development of embryos 24 hours old. Confronting embryos of different ages, it was noted that the same quantitative effect was obtained with doses proportional to the age of the embryos; thus, for ex., one observe the same mortality effect in embryos 30-min old irradiated with 300 rad as in those 24-h old treated with 4800 rad.

The results obtained are presented and discussed.

58.2. AZADIRACHTINS, CHEMICAL PROBES FOR THE INSECT  
10 ENDOCRINOLOGIST

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A group of azadirachtins has been isolated from the seed of Azadirachta indica. These tetranortriterpenoids interfere in a specific way with insect growth and metamorphosis. Data will be presented about mammalian clearance and insect metabolism for some of these compounds. Studies with Locusta migratoria and Epilachna varivestis demonstrate an interference with the neuroendocrine control of the peripheral JH- and ecdysteroid titres which ends up with a disturbance of developmental programs. Binding kinetics support the possibility of an interference with the feed back control of ecdysteroid titres. The suitability of the azadirachtins as chemical probes for the study of hormonal control systems in insect metamorphosis will be discussed on the basis of these data.

58.2. ECDYSTEROIDS IN OVARIES AND EMBRYOS OF BOMBYX MORI  
11

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Ecdysteroids, steroids having the molting hormone activity or their analogues, have been found in embryos and ovaries of various insects. In the silkworm, Bombyx mori, ecdysteroids accumulate in ovary during maturation. After oviposition, they gradually decrease in amount and disappear at emergence. Major components in ovary consisted of 2-deoxyecdysone, 2-deoxy-20-hydroxyecdysone, 2,22-dideoxy-20-hydroxyecdysone, ecdysone, 20-hydroxyecdysone and several unknown compounds in free and conjugated forms. Ovaries and embryos seem to have quite high activity in biosynthetic as well as metabolic transformations of the ecdysteroids.



**58.2.** ENDOCRINE ASPECTS OF EMBRYOGENESIS IN THE OVOVIVIPAROUS COCKROACH  
**12** NAUPHOETA CINEREA

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Embryonic development lasts 35 to 40 days in *Nauphoeta cinerea* and we have observed a first short increase in the titre of 20-hydroxyecdysone in the absence of juvenile hormone and concomitant with the formation of an embryonic cuticle around day 18, when dorsal closure normally occurs. The pronounced increase in 20-hydroxyecdysone registered at the time when the first larval cuticle is formed ensues, however, in the presence of high concentrations of juvenile hormone III and also of methyl farnesoate, both synthesised and released by the embryonic corpora allata. These observations together with juvenile hormone III application experiments suggest that juvenile hormone III plays a role in larval cuticle formation in the embryo. This possibility and other potential functions of juvenile hormone III and methyl farnesoate will be discussed in relation to their titre variations.

**58.2.** ROLE OF HORMONES DURING EMBRYOGENESIS OF ONCOPELTUS PROBED  
**13** BY INSECT GROWTH REGULATORS AND EXOGENOUS HORMONES

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Ecdysteroids, juvenile hormone (JH) and neurosecretions are present during embryogenesis of Oncopeltus fasciatus. Their role, however, is poorly understood. The size of the embryo prohibits an operative approach. Insect growth regulators which may act as "anti-JH", "anti-ecdysteroid", or may inhibit release of neurosecretions appear therefore as welcome tools to probe hormone function during embryogenesis. Precocene, azadirachtin, diflubenzuron and penfluron were tested with this goal. In addition effects of exogenous ecdysteroids and JH were studied. The results suggest that JH plays a role in the process of dorsal closure. Makisterone A, the biologically active ecdysteroid in Oncopeltus, accelerates early development. Further observations are discussed.

**58.2.** RELATIONSHIP BETWEEN THE TRICHOPTERA AND LEPIDOPTERA FROM  
**14** EMBRYOLOGICAL STANDPOINT

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As the results of the comparative studies on the embryonic development of caddisflies and primitive moths belonged to the Annulipalpia, Integripalpia of Trichoptera, and the Zeugloptera, Dacnonypha, Exoporia and Monotrysia of Lepidoptera, it is confirmed that types of the germ rudiment formation and some other characters have important phylogenetical significances to consider about the relationship between the two orders.

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**58.2.** POSSIBLE INVOLVEMENT OF CYTOSKELETAL ORGANELLES IN  
**15** BLASTODERM FORMATION OF THE SILKWORM, BOMBYX MORI

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We have investigated blastoderm formation in the silkworm, Bombyx mori (S. Takesue et al, J Embryol exp Morphol 60(1980)117; Wilhelm Roux's Arch 192(1983)113). This work deals with localization of cytoskeletal organelles during blastoderm formation by immunofluorescence microscopy using antibodies against tubulin and actin, as well as by electron microscopy, and effects of colchicin and cytochalasin B on blastoderm formation.

Anti-tubulin stained the cytoplasm associated with cleavage nuclei either migrating to or protruding from the egg surface, in accord with an electron microscopic observation showing many microtubules in the associated cytoplasm. Anti-actin stained the interior-located cytoplasm not associated with the nuclei and microprojections on the surface. Anti-actin also stained yolk granules in the peripheral region. When the egg was incubated with colchicin, the nuclei stopped dividing and migrating, but the periplasm lined with the microprojections developed into nucleus-lacking blastoderm cells. Such structures were not induced by the incubation with cytochalasin B.

These results suggest involvement of the cytoskeletons in blastoderm formation and autonomous changes of the egg surface.

**58.2.** CELL MIGRATION DURING EARLY EMBRYOGENESIS IN APIS MELLIFERA  
**16** (HYMENOPTERA)

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Migration of cells and epithelia plays an important morphogenetic role in the construction of the honey bee embryo and its envelopes. The pre-serosa forms from dorsal blastoderm cells and from additional cells which migrate into the cell-free dorsal strip of the posterior egg half. Its free edges move over the germ band and meet ventrally to form the serosa while the free edges of the germ band extend dorsally as a thin epithelium which fuses over the yolk system where it forms the amnion. At the same time, the entoderm cells travel in loose formation on the yolk surface underneath the amnion and later on join up to envelop the yolk as the midgut epithelium. Each of these movements is characterized by its specific syndrome of cell shapes and cell contacts at the leading edge and behind it.

**58.2.** ULTRASTRUCTURAL STUDY OF PREBLASTODERM DEVELOPMENT IN THE SCREWORM FLY,  
**17** COCHLIOMYIA HOMINIVORAX (Coquillett) (Diptera: Calliphoridae).

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Cytological events during preblastoderm nuclear division in the screwworm fly were examined after 60 minutes of development using light and electron microscopy. The 60 minute embryo is the product of 6 to 7 nearly synchronous nuclear divisions at 20°C. At the onset of the division process, intranuclear microtubules radiate from the poles toward the equatorial plane and presumptive centrioles are present. The microtubular array disappears and the nucleus takes on an irregular shape with lobe-like projections. At this time, the chromosomes appear oriented in line with the lobe-like projections and attached to the nuclear envelope. The nuclear envelope is elevated where the chromosomes attach to form a protusion into the cytoplasm. The space between the inner and outer membranes of the nuclear envelope contain fibrillar material that contacts the chromosomes. During the division process the nuclear envelope becomes incomplete and no barrier between the cytoplasm and nucleoplasm is evident where gaps occur in the nuclear envelope. Also, nuclear pore complexes form in the vesiculated zone between the nucleoplasm and cytoplasm. Presumably, nuclear pore complexes are conserved and provide a pool of pores for the daughter nuclei. The explanation of poleward movement of chromosomes by microtubules is inadequate to explain karyokinesis in the screwworm fly preblastoderm embryo, since a spindle fiber apparatus consisting of microtubules is absent during the final elongation and division of the nucleoplasm. An explanation is offered using a model previously published by the authors.

**58.2.** PULSATILE MOVEMENT OF DEVELOPING EMBRYONIC HEART IN THE  
**19** WATERSTRIDER, GERRIS PALUDUM INSULARIS.

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In Gerris the embryonic heart is derived from the cardioblasts which meet along the mid-dorsal line of the embryo after katatrepsis and subsequently fuse with each other to form a tubular structure; alary muscle fibers derived from sibling mesodermal cells of the cardioblasts stretch between the embryonic heart and abdominal wall. Functional development of the embryonic heart as indicated by its pulsatile movement, which may only clearly be revealed after cinematographic observation, has been seen to occur at about 72 h(20°C) after katatrepsis, in close association with 'swinging movement' of the embryonic abdomen. Further functional as well as structural development of the embryonic heart in Gerris will be reported in detail.

**58.2.** STRUCTURE AND DEVELOPMENT OF LARVAL ANTENNAL SENSILLA IN  
**20** EMBRYOS OF LYTTA VIRIDANA (COLEOPTERA, MELOIDAE)

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At hatching (252-264 h at  $25 \pm 0.5^{\circ}\text{C}$ ), each larval antenna has 3 flagellomeres and bears 17 sensilla of 6 different types. The antennae first appear at 48 h as paired evaginations on either side of the stomodaeum. Sensillar stem cells originate in their walls by 72 h, and these proliferate until about 112 h when most of their progeny begins to differentiate into sensory neurons and sheath cells.

Following katatrepsis (112-120 h), the sensory dendrites of each sensillum grow towards the surface of the epidermis and contact the inner side of embryonic cuticle 2 when this begins to be deposited at 120 h. With apolysis of this cuticle at 132 h, both dendrites and inner sheath cells elongate and the latter deposit a dendritic sheath about each group of dendrites that is continuous with the cuticle. Between 132 and 144 h, trichogen cells form the definitive sensilla and larval cuticle begins to be secreted about these after 144 h. Dendritic contact with embryonic cuticle 2 is maintained until shortly before hatch through pores in the apical or basal cuticle of the larval sensilla. Basal bodies and ciliary rootlets of the dendrites first appear between 112 and 120 h while scolopales of the Johnston's Organ are secreted between 144 and 168 h. Differentiation of sensilla is essentially complete by 192 h.

**S8.3.** PARENTAL AGE EFFECTS ON THE OLIVE FRUIT FLY'S, *DACUS OLEAE*,  
**3** ADULT PROGENY

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The effect of age of parent olive fruit flies, *Dacus oleae*, on the adult progeny's longevity, fecundity and fertility was investigated. Parental age ranged from 5 to 50 days. The survival rate of adult offspring was not affected by increased parental age. Egg production and fertility, on the other hand, were significantly decreased with increasing parental age, ranging from 19.6 to 12.6 eggs per female per day, and from 88.0% to 65.0%, respectively.

**S8.3.** INFLUENCE OF THE EYE ON THE LIFE-SHORTENING EFFECT OF UV-  
**4** RADIATION IN *DROSOPHILA MELANOGASTER* ADULTS :

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It has been speculated that UV-induced damage to the eye is responsible for the UV-induced life-shortening in the adults of *Drosophila melanogaster*. The present study was conducted to explore the influence of eye color and the absence of the eye on this effect. Young adults of both sexes of isogenic strains of white eye, eyeless and Oregon-k wild type were exposed to a series of different doses of UV-radiation at a distance of 10cm from the source [dose rate =  $262.5 \text{ ergs/cm}^2/\text{sec.}$ ], and their bidaily mortality rates were noted from which the mean lifespan was calculated.

Regression analysis of UV-dose/mean lifespan relationship indicate that for all strains tested, males and females are equally sensitive to UV-radiation. Pigmentation of the eye has little influence on the UV-induced life-shortening since white eyed flies showed similar response as the wild type strain. On the other hand, the results clearly revealed that absence of the eye led to a significantly increased degree of life-shortening effect of this radiation. Looking at the results as a whole, it seems obvious that the obtained data does not support the above mentioned speculation. In fact, the results suggest that the presence of the eye, of any color, plays a protective role against the direct effect of UV-radiation on the cephalic ganglion of the fly.

**58.3.**  
**5** REPRODUCTION AND PROTEIN INTAKE AS DETERMINANTS FOR THE AGE DEPENDENT LOSS OF FLIGHT PERFORMANCE AND NUTRITION BEHAVIOR OF THE BLOW-FLY *P. TERRAE NOVAE*

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The blowfly *P. terrae novae*, an anautogenous insect, exhibits like other dipterans a strongly programmed adult life cycle. Regarding the physical activity a sudden drop in flight performance after the third part of adult life can be observed. This loss of vitality in both sexes is intimately but in different ways correlated: i. with the ability to reproduce and ii. with the availability and time of first ingestion of protein. A protein meal reduces the flight distance per unit time whereas copulation triggers the onset of the rapid decline of flight performance. Both effects act together in protein fed mated females and lead to the earliest dropping of flight performance when compared with protein fed or protein deficient virgin females. The same is observed among male flies. Protein intake and probably copulation not only have influence on flight performance but are also determinants for the amount of sugar ingestion which itself is age dependent. The simultaneous possibility of protein and sugar intake doubles the sugar intake for about three weeks. A delayed initial protein dose leads to a rise in sugar intake immediately after the time of protein ingestion. In protein deficient flies the ability to copulate tends to increase the sugar ingestion, but only during the first week of adult life. Evidence exists that at least the onset of loss of flight ability is under hormonal control which in turn is expressed on the metabolic side by different variations of phosphorylase activities of mated and unmated flies.

**58.3.**  
**6** THE INFLUENCE OF REPRODUCTION ON LIFE SPAN AND ENERGY METABOLISM OF THE FAT BODY IN *PHORMIA TERRAE NOVAE*

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Life span and vital processes of *Phormia terrae novae* females are influenced mainly by two events: namely mating and protein meals. The occurrence of both causes a high production rate between the 10<sup>th</sup> and 14<sup>th</sup> day after emergence and results in a maximum life span of  $21 \pm 4$  days. Correlated with egg production is a decrease of fatbody glycogen content of 70 %, a decline of glucose and trehalose at the same rate and an increase in phosphorylase an activity of about 80 %. Simply by giving a protein meal life span is increased by about 10 days ( $31 \pm 3$ ) and the maximum reproduction rate is reached between the 18<sup>th</sup> and 21<sup>st</sup> day after eclosion. In this case there is also a correlation between the rate of egg production and metabolic parameters mentioned above. In addition to these differences in time the animals of both populations also differ in the number of eggs and the content of carbohydrates. These results indicate that life span and fatbody metabolism is under hormonal control by the brain and its neurosecretory glands and the regulation of reproduction by factors from the brain and the ovary and its secretory cells.

### **58.3.** SENESCENCE IN STRIATED MUSCLE IN MUSCA DOMESTICA, L.

**7**

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In evaluating mechanisms of senescence in dipteran striated muscle, a number of factors need to be considered, such as dormancy and the cause of insect death. An important factor in the death of male Musca domestica, L. was found to be damage to their chemotactic legs, resulting in a mortality curve similar to that expected using a rate-of-living hypothesis. When females were used, under the proper conditions, senescence was observed in muscle function. Studies of this tissue, utilizing electron microscopy, freeze-fracture analysis and biochemical analysis resulted in a theory ascribing the loss of cell function to mitochondrial membrane components.

### **58.3.** OXIDATIVE STRESS AND AGING

**8**

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Relationship between metabolic rate and aging was examined in the adult male housefly. Physical activity was altered by a variety of regimes and was measured by a radar-Doppler. In all cases, reduction in physical activity extended the average and the maximum life span of populations. Flies exhibiting greater tendency for spontaneous flying lived longer than the less active lazy flies. Metabolic rate also affects the rate of age-related cellular changes. Rates of accumulation of lipofuscin, soluble fluorescent material and thiobarbituric acid-reactants were slower under conditions of relatively low physical activity. To investigate if the effects of metabolic rate are due to the involvement of oxygen radicals, effects of oxidative stress were examined. Superoxide dismutase (SOD) and catalase activity and concentration of reduced glutathione (GSH) decreased during later half of life, whereas, levels of inorganic peroxides and oxidized glutathione increased with age. Experimental reduction in activities of SOD and catalase had no effect on life span. In general, houseflies responded to oxidative stress by lowering of metabolic rate and elevation of GSH. Overall, the results suggest that metabolic rate may be a factor in influencing the aging process.

Supported by National Institutes of Health.

### 58.3. AGE AFFECTS THE METABOLIC RATE OF INSECT BRAIN

10

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Due to their special organization (lack of blood vessels, direct access of  $O_2$  to the tissue by tracheae, stores of glycogen) insect brains can be studied *in vitro*. The rate of  $O_2$  consumption of isolated brains of the blowfly (*Calliphora erythrocephala*) is markedly affected by the age of the animal. The initial rates of  $20 \mu l O_2 / mg$  dry tissue/h at  $25^\circ C$  in females and males resp. increase steadily during the first half of the life span to reach maximal values of about 25 and 45 around day 20. Then the activity suddenly drops to the initial level and stays rather constant until death occurs. This pattern is roughly parallel to the  $O_2$  uptake rate of whole intact flies under resting conditions. Electron microscopy revealed differences in nerve and glia cells between 5, 18, 39 days old brains. Most conspicuous were large clusters of mitochondria in the middle aged brains and accumulation of lipofuscin like material in the old ones. The structural differences seem to be accompanied by changes in mitochondrial respiration in the 10.000g sediment of gently homogenized brain tissue. Supported by DFG, Bonn.

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### 58.3. PROTEIN SYNTHESIS IN THE INTRACELLULAR SYMBIONTS OF THE APHID

11

IS CONTROLLED BY THE HOST AGE-DEPENDENTLY

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Intracellular symbiosis in the aphid mycetocyte is a good model in which to study the origin of DNA-containing cell organelles. The symbionts isolated from the pea aphid, *Acyrtosiphon pisum* can synthesize DNA, RNA and protein *in vitro* quite actively. By resolving on two-dimensional gel electrophoresis, it was revealed that the symbionts synthesize *in vitro* numerous species of protein. By contrast, the symbionts *in vivo* synthesize an only protein species, symbionin, which was demonstrated by injections of antibiotics and radioactive precursors into the host insects. Symbionin, an acidic protein with mol. wt. of 63 K, was not among those synthesized *in vitro*.

When the pea aphids are maintained at  $15^\circ C$  in a short-day regime (12 hr photo-period), they begin to produce offspring at about 13 days old. Though no longer productive at about 40 days old, they live up to the 65th day if cared well. It was shown in this study that in the course of ageing of the host insect the protein synthesis by the symbionts *in vivo* was dramatically changed. As the host got older (45 days-old or older), the synthesis of symbionin by the symbiont was lowered markedly. Instead, syntheses of several proteins which are among those synthesized *in vitro* became apparent even *in vivo*. This situation was reproduced by keeping the young hosts under the influence of cycloheximide for 48 hr. It is likely that some proteinaceous factors are involved in regulating expression of the symbiont genome *in vivo*.



**58.3.** REGULATION OF FAT BODY CARBOHYDRATE METABOLISM IN  
**12** AGING MALE PHORMIA TERRAE-NOVAE

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The influence of endocrine factors of the corpora cardiaca on the glycogen metabolism of the fat body of the male black blow-fly *Phormia terrae-novae* during aging has been studied. The specific activity of fat body phosphorylase during the first ten days of adult life follows a pattern which is similar to that of the "energy spending" enzymes, Trehalase and Arginine-phosphokinase with a maximum at the 6<sup>th</sup> day. Incubating fat bodies of different ages with corpora cardiaca homogenates of 6 day old flies leads to an increase of specific phosphorylase activity of about 40%. Adenylatcyclase and cyclic AMP were investigated in relation to age. cAMP reached its maximum concentration on the 6<sup>th</sup> day; ADC showed a maximum of specific activity at the 11<sup>th</sup> day. When corpora cardiaca homogenates of flies varying in age were injected into 10 day old acceptors the maximum hormon activity was found to be between the 9<sup>th</sup> and 12<sup>th</sup> day. The observed effects on cAMP metabolism in the fat body cell may be due to an age-related control of neurohormonesecretion by the brain.

**58.3.** SHORT LIFESPAN AND DE NOVO SYNTHESIS OF UREA IN THE  
**14** SILKMOTH, BOMBYX MORI, REARED AT HIGH TEMPERATURE

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When reared at the optimal temperature of 25°C, urea is not present in the body of the silkmoth except for a slight amount in the secreted meconium. In silkmoth reared at the higher temperature of 35°C, however, an extraordinary accumulation of urea occurs accompanied by a reduction in lifespan by one half. Undoubtedly, urea is produced in this terrestrial insect, although the accumulation mechanism is not clear. By rearing at high temperature, protein degradation may be accelerated, resulting in increased amounts of free arginine, which could cause the active production of urea. This possibility would be a counterargument to the rate of living theory relating to longevity and temperature. However, at least the above facts signify that an extrinsic factor is influencing the longevity of an animal by altering its intrinsic aging process.

58.3.  
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### AGEING AND FLIGHT PHYSIOLOGY IN LOCUSTA

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The major fuel for locust flight is diacylglycerol mobilised from the fat body in response to release of AKH (adipokinetic hormone). Newly emerged locusts, however, fly poorly in the laboratory, do not mobilise lipids in response to AKH injection, and the levels of haemolymph proteins which transport lipid to the flight muscles are low. During somatic development the AKH response improves in parallel with increases in titres of haemolymph proteins and lipoproteins and activities of flight muscle enzymes concerned with lipid utilisation. This is reflected in the attainment of maximum flight ability by c. day 18. Removal of the corpora allata delays full development of the hyperlipaemic response to AKH and optimum flight performance. The presence of the corpora allata is not an absolute requirement in the adult for the development of flight processes, but their removal prolongs the time course of development. Flight ability declines as locusts age and this may be due to deficiencies in the lipoprotein transport system. The importance of lipid mobilisation, transport, and utilisation during flight will be discussed in relation to flight performance and the roles of hormones in the ageing process.

58.3.  
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### DIETARY STEROLS AND AGING IN XYLEBORUS ADULT FEMALES

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Xyleborus are excellent models for steroidal studies because they require a dietary  $\Delta^7$ -sterol. These insects especially require such dietary sterol as a precursor for ecdysteroid biosynthesis. Striking ultrastructural and hormonal parameters of premature menopause and aging were observed in adult female Xyleborus ferrugineus fed cholesterol, rather than 7-dehydrocholesterol, as a sole dietary sterol. Titer of free ecdysteroids in such 63-day-old females increased normally during the ovarian cycle, but remained abnormally elevated. A similar plateauing of the peak titer occurred in such irregularly cycling 147-day-old females. After 210 days, no significant change in titer of free ecdysteroids occurred during the next 9 days after the females were put on a new batch of such diet, when the ovarian cycle normally would occur. With all studied ages of adult female X. ferrugineus that received 7-dehydrocholesterol as the sole dietary sterol, the titer of free ecdysteroid returned to a basal level after peaking in each cycle. Thus, females receiving 7-dehydrocholesterol remained hormonally responsive in ovarian cycles through 210 days of age. The observed hormonal changes in menopausal beetles on cholesterol diet seem especially analogous to the elevated levels of  $17\beta$ -estradiol through the estrous ovary of aged irregularly cycling rats. The highly abnormal ultrastructure of ovaries of X. ferrugineus females aged 216 days on diet containing cholesterol as the sole dietary sterol seems quite analogous to that of the nonovulatory follicles in older, irregularly cycling rats.

**P8.1.-**  
**1** THE ROLE OF THE JULLIEN ORGAN, ACCESSORY GENITAL PIECES  
OF SOME SATYRIDAE (LEPIDOPTERA).

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The Jullien organ, which consists in a series of tiny rods implanted at the posterior end of the male 8th abdominal tergum, are characteristic of the genus *Hipparchia* and of some species of the genus *Maniola*. The precise role of these unique structures in mating was studied by means of optical, scanning and transmission electron microscopy. These rods seem to be highly modified scales and their role could be multiple in mating. According to the ultrastructure of their trichogen cells, these rods could be implicated in the production and dispersion of a pheromonal product, as it is of the same type as that described in the scent scales of the butterfly *Caligo*. On the other hand, according to the size and hardness of this organ, it seems reasonable to think of a mechanical role in copulation, and this is studied by comparison with the morphology of other parts of the genitalia (valves, uncus).

**P8.1.-**  
**2** SOME FACTORS INDUCING MALE SEX DETERMINATION IN THE APHIDS *MEGOURA*  
*VICIAE* BUCKTON AND *ACYRTHOSIPHON PISUM* HARRIS.

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A comparative study on the determination of male sex has been carried out in two species of aphids, *Megoura viciae* Buckton and *Acyrtosiphon pisum* Harris.

In addition to photoperiodic length the influence of some other factors such as fasting, temperature variations and host plant, has been studied.

Although the utilised strains gave no male births in long photoperiod regime some males were born when parthenogenetic mothers were subjected to appropriate fasting treatments.

**P8.1.-** MIDGUT METAMORPHOSIS AND EFFECTS OF A JUVENILE HORMONE  
**3** ANALOGUE IN THE MEALWORM TENEbrio MOLITOR

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During the pupal molt of the mealworm the whole midgut larval epithelium along with the basement layer is rejected and the connective fibers partially disappear whereas a new epithelium is set up.

A slow differentiation of the midgut wall then occurs which appears disturbed after treatment of very young pupae by a juvenile hormone analogue (ZR 515). Alterations observed include 1) anarchic organization of the epithelium due to a cell proliferation without growth of the regenerative crypts characteristic of the adults ; 2) reduced development of both the new basement layer and connective fibers ; 3) poor differentiation of myofibroblasts into a third muscular layer ; in correlation with 4) a fall of protein, especially collagen, synthesis levels.

**P8.1.-** METABOLIC SHIFT OF FAT BODY TOWARD THE LARVAL-PUPAL METAMORPHOSIS  
**4** IN THE SILKWORM, *BOMBYX MORI*

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By the *in vitro* incubation of fat body with  $^{14}\text{C}$ -glucose which seems to be the initial substrate for energetics of the silkworm, biosynthetic activities of lipids and glycogen were followed through the last larval instar to pupal-metamorphosis. The incorporation was predominantly found in lipids at the earlier stage of fifth instar and was then transferred into glycogen at the last stage. Thus the larval fat body is metabolically specified by the elevated lipogenesis and the metabolic shift to glycogen synthesis is responsible for larval maturation. Administration of juvenile hormone could clearly disturb such a sequential metabolic shift in fat body.

From these results, we consider the developmental programs which are concerning to the metabolic transition of fat body of the silkworm.

**P8.1.-** EXTREMELY HIGH ARGINASE ACTIVITY IN THE VESICULA SEMINALIS  
**5** OF THE SILKMOTH, BOMBYX MORI. SEXUAL DIMORPHISM OF ARGINASE.

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Bombyx mori silkmoth arginase was investigated in 32 various laboratory strains inclusive of several mutants. The activity in male moths was higher than in comparable females in either strain. The average for male moths was six-fold (activity per individual) or 15-fold (activity per mg protein) greater than that for female moths. Sex difference in arginase activity in adult silkworm results from extremely high activity in the vesicula seminalis of the male moths. The activity in this organ occurs in late pupal stage and increases with the development of the organ. The number of spermatozoa in the vesicula seminalis also increases during this period. The activity is kept at high level during adult life time with the maximum in two-day-old moths.

**P8.2.-** HONEY BEE EMBRYOGENESIS AS SEEN IN THE SCANNING ELECTRON MICROSCOPE  
**1**

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The embryonic development of Apis mellifera (Hymenoptera) was analyzed with the scanning electron microscope. Besides visualizing many features inferred previously from light microscopical observations, our study has revealed several new details. The process of blastoderm formation starts near the anterior end (cleavage center) and spreads as a wave preceded by specific configurations of microvilli. Segmentation becomes manifest during gastrulation, in the mesoderm even before its internalization. Moving epithelia are characterized by specific cell shapes at their leading edges (see abstract by R. Fleig). The anterior midgut rudiment segregates during gastrulation as a shallow circular depression distinct from the prospective mesoderm. The incipient Malpighian tubules show as pits on the hindgut anlage before its invagination. Other pits give rise to internal parts of the skeleton. Some of these pits remain visible even in the first larval instar while the tracheal invaginations are sealed off by the cuticle before hatching.

**P8.2.-**  
**2** EARLY DEVELOPMENT OF NORMAL AND EXPERIMENTALLY DEFORMED NAKED EGGS OF  
A PAEDOGENETIC DIPTERAN INSECT

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The eggs of the gall midge Heteropeza pygmaea develop parthenogenetically inside of the mother larva. They are not provided with a chorion, and the cleaving eggs remain enveloped by the follicular epithelium. After experimental elimination of the follicular epithelium "naked" eggs are formed, which attain the blastoderm stage but remain spherical instead of assuming the normal elongated shape. The ultrastructure of both kinds of cleaving eggs has been studied.

The number of elements of Golgi apparatus and endoplasmic reticulum strongly increases during early cleavage. Their association with cleavage furrows and nuclei suggests a preponderant role of these organelles in membrane production. Egg yolk consists of lipids and glycogen, whereas proteins are absent. Cleaving eggs contain numerous lysosomal vesicles indicating intense autophagic processes. Cleavage furrow formation is independent from the positioning of the cleavage nuclei. The formation of cleavage furrows, the establishment of the blastodermal layer and the localization of yolk in the central part of the egg are accurately accomplished in naked spherical eggs. Thus, these processes can be considered as independent from the normal egg shape and from the follicular epithelium.

**P8.2.-**  
**3** SKANNING ELECTRON MICROSCOPY OF TETRODONTOPHORA BIELANENSIS  
/WAGA/ /COLLEMBOLA/ EMBRYOGENESIS. APPENDAGES FORMATION AND  
GERM BAND SEGMENTATION

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First thoracic appendages form, as papilla-like evaginations, then head and abdominal ones subsequently. The most conspicuous appendages are the antennae. The invagination of the stomodaeum occurs as deep rounded groove. Blastokinesis occurs when appendages are already well differentiated and when segmentation begins. The blastokinesis is a simple process, involving neither rotation or revolution. In the process of blastokinesis most probably the dorsal organ is engaged.

**P8.2.-** SCANNING AND TRANSMISSION ELECTRON MICROSCOPY OF TETRODONTOPHORA  
**4** BIELANENSIS /WAGA/ /COLLEMBOLA/ EMBRYOGENESIS. BLASTODERMAL CUTICULES

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During embryogenesis of the species studied, between 30 - 90 days after oviposition, two acellular blastodermic cuticules form.

The formation of the first cuticle and its structure is described in details. According to the second cuticle only the beginning of formation and mode of its folding is analysed.

**P8.2.-** SEXUAL BEHAVIOUR AND OVIPOSITION OF LONGHORNED DRY WOOD BORER,  
**5** STROMATIUM BARBATUM (FABR.) (COL. : CERAMBYCIDAE: CERAMBYCINAE )

S.N. PAL

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Sexual behaviour and oviposition of longhorned dry wood borer, Stromatium barbatum (Fabr.) have been investigated at 30°-32°C and 75-85% R.H. from dusk to night.

A selection of partner by antennal contact and courtship is described. Stimulation of female performed by male as "licking and tapping" of female elytra, abdominal movements and pulling out of ovipositor. Several types of antennal movements in male and biting by male to the head and elytra of female have been found during copulation. Mating terminates after 1-3 minutes, whereas male may remain on female for some hrs. to 20 hrs. in "amplexus". Running or short flight of the female to throw off the male after copulation is discussed.

Female lays 75-250 eggs on smooth surface, in small holes, crevices or fissures in wood and on non-host substratum like craft paper in absence of host-wood. The ability of female to determine the suitability of wood for larval development is described and so-called "tasting" marks discussed.

**P8.2.-** ROLE OF CORPORA ALLATA AND OVARIES ON THE ONSET OF RECEPTIVITY  
**6** IN THE FEMALE HOUSE CRICKET ACHETA DOMESTICUS

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The females of Acheta domesticus are able to mate from the 40th hour after imaginal moult. At that time JH III has already been synthesized and released in the haemolymph whereas ecdysteroids appear in the haemolymph as well as in the ovaries on day 2 only. Removal of either the corpora allata or the ovaries or both, after or before the imaginal moult do not prevent mating and indicates that ovaries and/or corpora allata do not play any essential role on the onset of the first sexual receptivity in this species, they apparently act mainly as modulators in the expression of the female sexual behavior.

**P8.2.-** EFFECTS OF COMBINED CENTRIFUGATION AND UV-IRRADIATION OF  
**7** EGG ON PATTERN FORMATION IN THE CHIRONOMUS EMBRYO.

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Types of abnormal embryonic development induced by centrifugation of the Chironomus egg are modified by the successive uv-irradiation of the centrifuged egg. Pattern of the modification is affected by the direction of irradiation and the irradiated stages. Such modification has also been reported in Smittia egg by Kalthoff et al ('82). However, the pattern of modification differs in detail from my results. Uv-effect of early anterior irradiation inducing double abdomen (DA) or inverted embryo (IE) is not photoreversible, while the effect inducing double cephalon caused by late posterior irradiation is photoreversible. These results show that a photoirreversible target concerning DA- or IE-induction lies in the anterior egg-half other than DA inducible, photoreversible target shown by single uv-irradiation studies (Kalthoff, '71; Yajima, '83).



**P8.3.-** THE INFLUENCE OF SEXUAL BEHAVIOUR ON THE AGE-RELATED METABOLIC RATE,  
**1** HORMON LEVEL, BRAIN METABOLISM AND LIFE SPAN IN THE SILKMOTH, B. MORI

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Silkmoths are unable to fly and do not feed as adults. During their short life span they draw upon energy stores, mainly fat gathered in the larval phase. The moths were kept at 25°C and 65 % rh in a longday (16:8h) either together in 1:1 sex ratio or separated immediately after eclosion.

Mated females have a maximal life span of 10 days, males live 7-8, unmated females 15, and males kept separately only 5 days. The different life spans are accompanied by different physiological parameters, for example, unmated females have a slow decrease in weight, a retarded deposition of eggs, a low metabolic rate, and diminish very slowly the titer of ecdysteroids. Separately kept males, which have no possibility to mate, are very active, have a high metabolic rate and a shortened life expectance. Cutting off the antennae drastically reduces the level of activity and prolongs significantly the life span.

The data demonstrate, that a lot of age-related physiological changes, like body weight, metabolic rate, brain metabolism, and ecdysteroid titer, are influenced by the sexual behaviour of the silkmoth. The chronological age is not identical with the physiological age if a 1:1 sex ratio is disregarded.

I thank Prof. F. ROMER for the cooperation by the radio-immunoassay.

**P8.3.-** RELATION OF INSECT LIFE SPAN TO BODY WEIGHT AND ENERGY METABOLISM  
**2** AND THE PROBLEM OF BRAIN WEIGHT, METABOLIC RATE AND LIFE SPAN

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Since SACHER (1959) many papers have been published relating body weight, brain weight, metabolism and life span, especially in mammals. In insects as in other animals the metabolic rate at rest is negatively correlated with body size. In order to test this relationship is valid also for insect brains we determined the respiratory rate of cerebral ganglia from 37 insect species of different body weight (6,9 mg - 24,7 g) at 20 % O<sub>2</sub> and 25°C.

1. As would be expected smaller species normally have smaller brains than larger ones, but the relation between brain and body size (index of cephalisation) decreases with increasing body size.
2. The respiratory rate, based on dry weight, is higher in the small ganglia from the smaller species.
3. In general, small insects with highly active brains have a shorter life span than larger insects with a large brain and a low metabolic rate.

The correlation between body size, brain metabolism and life span is complicated by factors other than body size or brain size.

Systematic position as well as living conditions obviously are connected with cephalisation index, metabolic rate of brain tissue and life span.

## **P8.3.-** INSECT BRAIN AS A MODEL FOR THE STUDY OF AGING<sup>+</sup>-

### **3** PHYSIOLOGICAL ASPECTS

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The leading role of the CNS in insect development is well established. It is however, an open question as to which extent this also applies for aging processes. In the whole animal kingdom, nerve cell function is based on the same principles and the structural and metabolic organization of nervous systems are remarkably similar. In general, brains have postmitotic cells and therefore all changes are age-related. For this reason, it is desirable to find experimental animals with well developed brains which can be studied under controlled conditions. Some insect meet these requirements and the advantages of insects as test animals for gerontological studies has been emphasized by several authors.

Insect brains are small, lack blood vessels and amply supplied with stored energy. Their metabolism is specialized on aerobic energy production and the metabolic rate is very high. Nevertheless, due to their remarkable metabolic stability, isolated insect brains will respire in vitro, and we have evidence that their respiratory rate is not changed by the experimental treatment. Knowledge about the physiology of aging insect brains may be helpful for a general understanding of the age-related changes in nervous tissues.

<sup>+</sup>HERMAN et al., Acta neuropathologica 19, 167-183 (1971)

## **P8.3.-** REGULATION OF CARBOHYDRATE METABOLISM IN RELATION TO AGE, **4** MATING AND FOODINTAKE IN THE MALE PHORMIA TERRAE-NOVAE

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The content of Phormia terrae-novae fat bodies in trehalose, glycogen, cAMP, phosphorylase, phosphodiesterase and adenylate-cyclase during adult life span has been studied. Both enzyme activities and metabolite concentrations increase from a low level at emergence, reaching a maximum during the first twelve days, and decrease to a low level which seems to be sufficient to enable a basic rate of living. All changes in enzymes and metabolites were found before 50% of the test population died. The control during the reproduction phase of fat body glycogen metabolism by factors of the corpora cardiaca is shown via incubation experiments with gland extracts of flies varying in age.

**P8.3.-**  
**5** Mating and Protein Intake: Influencing Life Span and Carbo-  
hydrate Metabolism in Female *Phormia terrae novae*

Wilps, H., Mehler, L., Mitschulat, H.

The carbohydrate metabolism of *Phormia terrae novae* female is influenced directly by the factors mating and/or protein meal. The activity profiles of Trehalase, Phosphorylase, Argininphosphate-Kinase and the increased or decreased concentrations of Trehalose, Glucose and Glycogen during life span are correlated directly to both factors. Mated females show a maximum of enzyme activity between the 6<sup>th</sup> and 9<sup>th</sup> day, whereas in unmated females this maximum of enzyme activity is shifted to the 10<sup>th</sup> to 14<sup>th</sup> day. The same correlation can be observed for the metabolite concentrations. Besides age dependent differences in the maxima of enzyme activity and metabolite concentrations there is also a difference to be seen in graphic height of both parameters.

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S 9.1.1. Techniques for Studying Insect Semiochemicals: Established and  
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## R9.1. EVOLUTIONARY STRATEGIES FOR PROCESSING PLANT ALLELOCHEMICALS 1 BY INSECT HERBIVORES

BLUM, MURRAY S.

Department of Entomology, University of Georgia, Athens, GA 30602

Phytophagous insects have evolved diverse mechanisms for processing potentially toxic allelochemicals that accompany ingested nutrients. Plant natural products may be directly excreted, or if absorbed, subjected to physiological and/or biochemical treatments that reduce their concentrations in the hemolymph. An interplay of metabolic, sequestrative, and excretory events characterizes the fates of various allelochemicals and emphasizes the idiosyncratic strategies evolved by each species for coping with secondary plant compounds.

## R9.1. PHARMACOPHAGOUS INSECTS 2

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Generally, plants are sources of nutrients for phytophagous insects, and secondary plant substances often mediate this herbivory. If the allelochemicals are sequestered by insects (e.g. for their defence), their uptake is usually linked with feeding behaviour. In contrast, pharmacophagous insects show associations with plants which are/can be independent of gathering energy and which concern the secondary compounds only; the respective plants do/need not serve the insects' primary metabolism but affect their fitness. Examples of insects utilizing pyrrolizidine alkaloids (PAs) are presented: several unrelated groups of Lepidoptera but also flea beetles and grasshoppers actively search for and take up PAs which can be stored for defence and/or used as male pheromone precursors. Specific morphogenetic effects of PAs are also found.

R9.1.  
3

## KAIROMONES AS CROP RESISTANCE FACTORS

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Heliothis armigera is a major pest of several crops. The use of pheromone traps for monitoring and for disruption of male-female communication can only interfere with the behaviour of the male insect. Kairomones however seem to be good candidates for trapping the females. Using a laboratory behavioural assay, an oviposition attractant has been partially purified from the pigeonpea, Cajanus cajan. Its function in pigeonpea resistance phenomena will be discussed as well as the use of this kairomone in field traps. A larval attractant has been partially purified from the chickpea, Cicer arietinum, by use of a laboratory assay. The possible use of these two compounds in pest management strategies will be discussed as well as first data on their chemical structure.

R9.1.  
4

## CHEMICAL, VISUAL AND TACTILE MIMETISM IN THE OPHRYS POLLINATION

BORG-KARLSON, A.-K., KÜLLENBERG, B., BERGSTRÖM, G., TENGÖ, J., ÅGREN, L.

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Orchids of the genus Ophrys are assortatively pollinated by aculeate Hymenopteran males. The males are attracted to make copulatory attempts on the flower labellum by means of chemical, visual and tactile stimuli. Chemical analyses of the volatile multicomponent secretion emitted from some species of the orchids and their corresponding pollinators, show a high degree of similarity (Sectio Fusci-luteae - Andrena spp. and O.insectifera - Argogorytes spp.). In the form complex O.fusca-O.lutea, the compounds in common have a high attraction capacity to the Andrena bee males in field tests. In the pollination-association Fuciflorae - Eucera, the chemical correspondance is not so obvious. Further aspects of the chemical, tactile and visual mimetism in relation to our present knowledge will be discussed.

**R9.1.**  
**5**

EVOLUTIONARY SIGNIFICANCE OF VARIABILITY IN OPHRYS (ORCHIDACEAE)-LEARNING EXPERIMENTS WITH PSEUDOCOPULATING BEE MALES

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Flowers of the orchid genus *Ophrys* mimick females of certain species of bees in order to attract pollinating males by imitating copulation-releasing optical, olfactory, and tactile signals. Since male bees of a particular species are attracted only to a particular species of *Ophrys*, this system simultaneously acts as a premating mechanism for different sympatric *Ophrys* species. A single male visits a special flower only a few times ignoring this flower further on. In some experiments with *Ophrys heldreichii* and its pollinator the longhornbee *Tetralonia berlandi*, we could demonstrate that the bees show Reiz-spezifische Ermüdung, probably real learning in its sexual behaviour on the flower. Pseudocopulation behaviour is only released by new flowers. The hypothesis is, that the variability of the flowers within one population is an answer of the orchid to that habituation behaviour of the pollinators which ensures more pollinations.

**R9.1.**  
**6**

HOST SELECTION IN THE CABBAGE ROOT FLY DELIA FLORALIS (ANTHOMYIIDAE):  
INTERACTION OF MOTIVATION LEVEL, CHEMICAL AND VISUAL CUES

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The sequence of host plant selection behaviour in Delia floralis was categorized into 1) landing, 2) proboscis extension response, 3) leaf search, 4) stem run, 5) ground search and 6) oviposition. Flies tended to spend the less time in each activity the further they proceeded in the sequence before leaving the plant, indicating the variability-increasing effect of motivation level. Ca. 15, 39 and 64 % of flies had rejected the plant after stages 1), 3) and 4), respectively; only 29 % laid eggs. On a dummy plant the percentages were 61, 92 and 96; 0. Flies landed with twice the frequency and half the time on host compared to dummy. Probability of proboscis response was increased by addition of plant odour to dummy, but average response time was not reduced. Tarsal contact with sinigrin and AITC enhanced both these parameters. Mean time of leaf search was 1.5-fold on host vs. dummy. The duration of stem run on dummy was 15-fold of that on host, but ground search took less time. Sinigrin together with plant extract inhibited egg-laying while AITC acted synergistically.

R9.1.  
7

## RESPONSES OF CABBAGE ROOTFLY TO HOST PLANT ODOUR

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The responses of the cabbage rootfly, Delia radicum (L.) to brassica odour presented in either the form of a discrete 'plume' or uniformly dispersed in air passing through a wind tunnel, were investigated. Upwind movement by gravid females, and to a lesser extent by males, occurred to a range of dispersed, host plant odour concentrations. Discrete plumes of allyl-isothiocyanate, a brassica volatile, were used to study host-locating behaviour. Gravid females released from various distances downwind of the odour source performed a zig-zag anemotactic flight in response to the plume, decreasing flight speed and turning more frequently as they approached the source. Flies released further away from the source covered the distance in two or more short flights.

9

R9.1.  
8

## THE INTERACTION BETWEEN CARRION FLIES AND SMELLING FLOWERS

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The flowering phenology, insect visitors, pollination efficiency and attractivity of the blossom extract of rowan (Sorbus aucuparia) and spindle-tree (Euonymus europaeus) growing at field edges were studied on the island of Öland, Sweden. At the rowan blossoms Coleoptera were more numerous before Diptera, Hymenoptera and other groups of insects were observed infrequently. The number of visitors reached the maximum in the afternoon. Pollination occurred diurnally in both plant species. A total of 64 insect species were observed to visit the flowers of spindle-tree. The proportion of carrion flies known to breed in the area was low among the visitors. We suggest that the carrion flies behave like "cruising taxidriviers" as flower visitors. The attractivity of smelling flowers is highly dependent on species composition of plants between and within sites.



## **R9.1.** SEARCH BEHAVIOR OF SUCROSE-FED MUSCA AND DROSOPHILA

**9**

WILLIAM J. BELL<sup>1</sup>, JEFFREY FROMM and JOEL WHITE

<sup>1</sup>University of Kansas, Lawrence KS 66045 USA

Consumption of a single drop of 0.25 M sucrose releases search behavior in both species of flies, characterized by increase in turning rate and decrease in locomotory rate followed by a return to control levels. Search patterns, digitized by computer, are convoluted and looping around the sucrose drop residue. Characteristics of search are more variable between individuals than within individuals tested on consecutive days. Duration of search increases with period of starvation, but the relationship is not a simple function. A "nutritional resource meter" is postulated that regulates search behavior relative to nutritional reserves.

Flies locating a series of sucrose drops change their motor patterns during a run to accomodate to different spatial arrangements of discrete resources in time and space. Experience gained from local search is utilized during a single search bout, but seems not to impact future search bouts. The data are interpretable in terms of adaptations for varying types of resource patterns in the environment

## **R9.1.** ALLOMONES FROM BERRIES OF THE CORNUS-, PRUNUS- AND LONICERA-SPECIES **10** INFLUENCING THE OVIPOSITION OF RHAGOLETIS CERASI

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Headspace-extracts of berries of *Lonicera cylostium* and *Prunus avium* cause an intensified oviposition of the cherry-fruit-fly in cherry-dummies, while extracts of berries of *Cornus sanguinea* and *Cornus mas* inhibit the oviposition towards non-manipulated dummies.

We analyzed extracts of the four berry-species by means of cappillary-GC-MS and partially by GC-FT-IR, and we identified a great number of substances. The structures of most of these substances is proved by mass spectra- and retention time-comparison.

By preparative gaschromatography we obtained fractions from the *Cornus-sanguinea*-extract which in the bioassay are significantly inhibiting oviposition.

We prepared a synthetic mixture with the main components of the *Cornus-sanguinea*-extract in the natural concentration. This mixture of 13 substances in the bioassay shows an effect significantly inhibiting oviposition. Extracts containing three or four components show a lower effect.

In the field the results can be confirmed only to a limited extent.

R9.1.  
11

ON THE NATURE OF LEARNING IN OVIPOSITION SITE ACCEPTANCE BY  
APPLE MAGGOT FLIES

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Earlier, we had found that after a female apple maggot fly, Rhagoletis pomonella, had arrived on a host fruit, its propensity to accept (bore into) or reject that fruit prior to egg deposition was modifiable through experience and hence involved learning. Here, we aimed to determine whether the true nature of the learned response was either (a) one in which a conditioned female, as a result of having become familiar with a particular fruit type, formed a greater propensity than had a naive female to accept that type in a future encounter, or (b) one in which a conditioned female formed no greater propensity than had a naive female to accept a particular fruit type but simply was less prone than a naive female to accept a novel fruit type. Results of each of 2 experiments support the latter hypothesis.

9

R9.1.  
12

BEHAVIOR AND SENSORY PHYSIOLOGY OF RHAGOLETIS POMONELLA IN RELATION  
TO OVIPOSITION STIMULANTS AND DETERRENTS IN FRUIT

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SEM studies revealed 10 chemosensilla and numerous mechanosensilla on the ovipositor of the adult apple maggot. Six of these are longer ( $2.7-5.5\mu$ ) than the other 4 ( $1.3\mu$ ) and are located about  $125\mu$  from the tip of the ovipositor while the shorter sensilla are located near the tip. The six longer chemosensilla are arranged in a groove located on each side of the ovipositor (3 sensilla/groove). TEM studies revealed 3-5 neurons/sensillum. Using over-the-tip recording techniques, several individual chemicals found in fruit were tested for possible stimulating or deterring properties. In conjunction with the electrophysiological tests, behavioral tests were performed using artificial fruits composed of various chemicals found in host apple fruit that were dissolved in agar spheres (dyed red). When solidified, the spheres were covered with a thin layer of parafilm and submitted to females for acceptance or rejection.

R9.1.  
13

HOST SELECTION AND LOCATION OF FEEDING TISSUES BY LEAFHOPPERS:  
BEHAVIORAL EVIDENCE FOR THE IMPORTANCE OF THE PRECIBARIAL SENSILLA.

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AND DONALD L. MCLEAN (ENTOM. DEPT., UNIV. OF CALIF., DAVIS, CA 95616 U.S.A.)

The precibarial chemosensilla of leafhoppers (Homoptera: Cicadellidae) are located along the path of fluid uptake, near the cibarium within the head. Successful ablation of these sensilla has been performed on the species Graphocephala atropunctata Signoret, with subsequent observations on its effects on feeding behavior, host recognition and the ability to locate a specific feeding tissue. Denervation of the sensilla was accomplished by surgically cutting through the cuticle of the clypellus, to sever the sensillar nerves below it. Such "ablated" leafhoppers were unable to distinguish between a plant which was highly preferred by control insects and one which was not preferred. Two-choice preference tests and electronic measurement of feeding behavior were the methods used to document this inability on the part of the "ablated" insects. It was found that "ablated" leafhoppers are usually unable to locate and ingest from xylem vessels, the normal feeding tissue of this species. Generally, the feeding behavior of the "ablated" leafhoppers on a preferred host plant resembled that of normal insects attempting to feed on a non-host plant or genetically resistant variety. Thus, the precibarial chemosensilla seem to play an important role in mediation of host selection.

R9.2.  
1

THE INTENSITY OF AREA-CONCENTRATED SEARCHING OF A  
LADYBEETLE VARIES WITH THE PREVIOUS FEEDING STIMULI

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A ladybeetle, Coccinella septempunctata, switched its searching behavior from extensive searching to area-concentrated searching (ACS) after consumption of an aphid prey (NAKAMUTA, 1982).

This switchover was elicited by contact with an agar block or an aphid. It was also elicited by biting an aphid or consumption of an agar block, on which a droplet of the aphid body fluid was spotted ("aphid" dummy). However, the duration of ACS varied with the previous feeding stimuli. The duration of ACS was longest after consumption of an aphid. Shorter periods were recorded after consumption of an "aphid" dummy and after biting (but not consuming) an aphid. ACS was shortest after contact with an aphid (without biting) or an agar block. The longer the duration of feeding time of an aphid or an "aphid" dummy, the longer the duration of ACS.

The sensory ability of the ladybeetle involved in prey detection is not highly developed (NAKAMUTA, in press). Therefore, it may be advantageous for the ladybeetle to "decide" the duration of ACS according to the value of the previous feeding stimuli.

R9.2.  
2

RESPONSE OF TWO PHYTOSEIID PREDATORS TO A KAIROMONE OF APPLE RUST MITE, *Aculus schlechtendali*: INFLUENCE OF FEEDING HISTORY.

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The Netherlands

The phytoseiid predators *Amblyseius potentillae* and *A. finlandicus* are known to effectively control the European red spider mite, *Panonychus ulmi*. They are also reported to use this prey as their main food source and to use apple rust mite (*Aculus schlechtendali*) and certain pollens as secondary food sources.

Using a Y-tube olfactometer it is shown that the two aforementioned predators walk upwind to the end of the arm with air blown over apple leaves heavily infested by apple rust mites.

In all experiments hungry predators are used. Nevertheless the response of the predators depends on the feeding history of the predators. A strain of *A. potentillae* reared on two-spotted spider mite (*Tetranychus urticae*) did not respond to odours from apple leaves infested by *A. schlechtendali*. Contrary a strain derived from the aforementioned one and reared on broad bean pollen did respond. *Amblyseius finlandicus* collected from a cherry orchard in which only *Tydeus sp.* was present on the leaves in low numbers did not respond to odours from leaves infested by *A. schlechtendali*; conspecific predators collected from leaves from a cherry orchard in which rust mites and European red spider mites were present did react.

The results indicate that a kairomone is emitted by *A. schlechtendali* from the infested leaves but that feeding history of the predators influences their response. We now study whether genetic differences exist or that the difference in reaction is a result of conditioning. The observed phenomenon may be of great importance for biological control programs.

R9.2.  
3 FACTORS INITIATING OR SUPPRESSING AERIAL DISPERSAL OF  
THE PREDATORY MITE *PHYTOSEIULUS PERSIMILIS*

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Release of the predatory mite, *Phytoseiulus persimilis*, in a spider-mite patch generally results in rapid build-up of the predator population, sooner or later followed by elimination of their prey. The majority of the predators do not disperse until after prey extermination. Though various ways of predator dispersal are possible, we have focussed on dispersal by air currents. Factors initiating or suppressing aerial dispersal were studied in a wind tunnel designed for observation of take-off behaviour of the predator on a small rose leaf. Percentage take-off increased with the period of food and water deprivation. Moreover, take-off was stimulated by low-humidity and high-temperature conditions during the deprivation period. However, take-off was largely suppressed when the predators were placed on rose leaves infested by spider mites during one day but freed of most webbing and all spider mites before use in the wind-tunnel experiments. Take-off was only slightly suppressed when the predators were placed on infested rose leaves that had the spider mites and the webbing removed 7 days before experimental use. Presumably, spider mites produce a kairomone which acts to suppress predator take-off. Hence, it can be concluded that this predatory mite is not blown off passively due to physical weakness, but that it can decide whether to stay in the prey patch or disperse by air currents.

9

**R9.2.** OLFACTORY MICROHABITAT LOCATION AND NICHE SEGREGATION IN  
**4** LARVAL ENDOPARASITIDS OF DROSOPHILIDAE.

LOUISE E.M. VET, K. BAKKER, J.J.M. VAN ALPHEN.

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Niche segregation in Alysinae (Braconidae) and Eucilidae larval endoparasitoids of Drosophilidae seems to be closely linked to differences at several levels of their searching behaviour. This presentation will only deal with olfactory selection of microhabitats. Habitat or microhabitat location is the first important decision for foraging parasitoids. Selecting a specific microhabitat may determine a parasitoid's host range. Olfactometer experiments with a four-armed airflow olfactometer showed that parasitoids are very specific in their response to microhabitat odours. Interspecific competition may lead to niche segregation via small differences in olfactory responses to these microhabitat odours.

**R9.2.** RESPONSES OF THE STABLE FLY (STOMOXYS CALCITRANS (L)) TO CARBON  
**5** DIOXIDE AND HOST ODOURS.

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The responses of the stable fly (Stomoxys calcitrans (L)) to CO<sub>2</sub> and expired human breath were investigated using a moving-air observation chamber and a slow-speed wind tunnel. Carbon dioxide causes an increase in random flight activity with a peak in the first minute of exposure, indicating that the change in the level of CO<sub>2</sub> is important in initiating flight activity in this species. Expired human breath causes a greater level of activity than predicted from its CO<sub>2</sub> content, due to a synergistic effect between CO<sub>2</sub> and other breath components. Carbon dioxide causes upwind flight only when it is added in such a way as to form a concentration gradient. Expired human breath causes upwind flight whether it is added to the tunnel in the form of a gradient or as a diffuse mixture throughout the airstream.

**R9.2.**  
**6** SIMILAR COEVOLUTIONARY PROCESS IN EUROPE AND UNITED STATES  
OF TWO TERMITOPHYLOUS ANTS OF THE GENUS PONERA, USING A  
CHEMICAL CRYPTIS

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Two ant species of the genus Ponera are common inside Termite nests of the genus Reticulitermes in Europe and North America. These two species avoid detection by its prey. The ant does not disturb termite workers and can move freely among them, before it attacks and immobilizes them with a very powerfull venom. Lethal doses 50 of Ponera were calculated in Laboratory tests on workers of R. flavipes, R. santonensis, R. (l.) grassei and R. (l.) banyulensis. The immobilized Termite is carried to a small chamber located inside the nest of its prey where larvae and nymphes of Ponera are nursed. A chemical mimicry enables the ants to move among the termites without being detected. In a nest, Termites only attack their predator during the sting behavior. In laboratory tests when Ponera came from a nest of an other Termite species, lethal doses 50 against workers were lower and the ants remained alive shorter than when Termites and Ants came from the same nest.

**R9.3.**  
**1** BEHAVIOURAL RESPONSES OF FEMALE LEPIDOPTERA TO MALE-PRODUCED SCENTS/  
PHEROMONES

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It is surprising that the effects of male pheromones on the sexual behaviour of female Lepidoptera are still poorly understood. It is assumed in all experimental work using sex pheromones that female scents stimulate the males of the species. The role of male stimuli during courtship are still only "presumed".

Pheromones produced by the male during courtship are less understood and have been described as stimulating variously: 1) female quiescence, 2) female acceptance, 3) suppression of sex pheromone release in female, 4) inhibition of responses of other males, 5) attraction of females, 6) initiation of female calling and pheromones release, and 7) numerous additional effects. We will discuss and delineate responses to male sex pheromones by female Lepidoptera and the aims and background of present research.

R9.3.  
2

THE EFFECT OF MALE SCENT OF MAMESTRA BRASSICAE (L) ON THE FEEDING AND DISPERSAL BEHAVIOUR OF CONSPECIFIC LARVAE

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Males of Mamestra brassicae possess a pair of scent brushes on the ventral surface of the first and second abdominal segments. These brushes disseminate a pheromone which contains benzaldehyde, benzyl alcohol and benzoic acid. The functions of this pheromone were largely unknown, except that the benzaldehyde component had been shown to inhibit conspecific larval feeding and that the pheromone per se was not necessary for successful courtship in this species. The results presented in this paper corroborate these findings and show that benzyl alcohol, benzoic acid and crude scent brush extract also inhibit feeding in larvae. And, in addition, these chemicals stimulate larval dispersal immediately post-hatching. It is proposed that the adult male of this species provides parental investment in the form of chemical protection of the eggs against disturbance and cannibalism by contaminating the oviposition site with his pheromone. Upon hatching the larvae disperse in search of food because the male pheromone has rendered the food in the vicinity of the eggs unpalatable. This may have the effect of reducing conspicuousness to potential predators, thus the likelihood of survival is increased. Therefore, the male pheromone of this species may be said to have an epideictic function that acts on a different phase of the life-cycle.

R9.4.  
1

VOLATILE SIGNALS IN THE DEFENCE BEHAVIOUR OF LARCH SAWFLY LARVAE (PRISTIPHORA ERICHSONII AND P. WESMAELI).

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The specific odor emission observed to accompany a characteristic defensive behaviour of larch sawfly larvae, "snap-bending", was studied in two species. Species-specific blends of monoterpenes, straight chain acetates and benzaldehyde are given off from ventral glands when the larvae are disturbed. Main components from P.e. and P.w. are bornyl acetate and 3-carene-10-ol, respectively. P.e. contains also tetradecyl-, hexadecyl- and octadecyl acetates, and benzaldehyde in large amounts. Other important components are, in P.e. borneol and trans-pinocarveol and in P.w. linalool and myrtenal. Results from the chemical analyses will be reported and comparisons made between the odor bouquets of the two species.

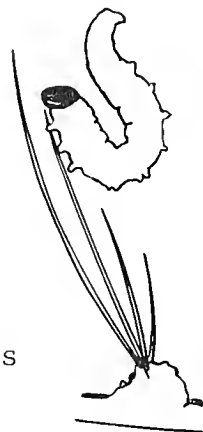
## R9.4. 2 SNAP-BENDING REACTION IN THE DEFENCE BEHAVIOR OF LARCH SAWFLY LARVAE

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Specific odor emission has been observed to accompany a characteristic defensive behavior of larch sawfly larvae: "snap-bending". This phenomenon has been studied in two species, Pristiphora erichsonii and P. wesmaeli. Behavior observations and experiments suggest that the combined visual-chemical signal has both a defence and an alarm function in the socially living P. erichsonii. Species-specific blends of monoterpenes and benzaldehyde are given off from ventral glands when larvae are disturbed. The main component in P. erichsonii is bornyl acetate and in P. wesmaeli -3-carene-10-ol. The P. erichsonii secretion also contains straight chain acetates.

Ecological and ethological features of the two larch sawfly species are compared. Tests with the volatile compounds on the larvae and on some of their predators are reported. Snap-bending reaction, single or in combination with other defence mechanisms, will be discussed.



9

## R9.4. 3 EVOLUTIONARY TRENDS WITH RESPECT TO THE DEFENSIVE CHEMISTRY OF THE ROVE BEETLE SUBFAMILY OXYTELINAE (STAPHYLINIDAE)

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Members of the rove beetle subfamily Oxytelinae are characterized by paired abdominal defensive glands where a host of defensive molecules is produced. Toluquinone, terpenoids, acids, several lactones and straight chained saturated and unsaturated esters are used as repellents against other attacking arthropods. In one species a polymerizing dialdehyde engluces small attackers.

Both the chemistry of the secretion and the defensive gland morphology have been shown to be highly correlated with the phylogenetic position of the beetle species investigated. Therefore it was possible to distinguish primitive and derived conditions of the chemical defensive systems.

Evolutionary trends have been shown especially with respect to the chemistry, biogenesis, activity and the physico-chemical properties of the defensive secretions.

Finally it was possible to construct a phylogenetic tree of the Oxytelinae according to the Hennig-principle by using characters of the defensive system.



**R9.4.**  
**4** EFFECTIVENESS OF CHEMICAL DEFENCE AGAINST PREDATORS IN LARVAE OF THE BUTTERFLY, PAPILIO XUTHUS: AN EXPERIMENTAL FIELD STUDY

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Papilio xuthus larvae like other papilionids have an osmetrium gland involved in their chemical defence. The effectiveness of the chemical defence against their predators, the Japanese tree sparrow, Passer montanus saturatus and the Japanese paper wasp, Polistes jadwigae was determined by exposing laboratory-reared 5th instar larvae of P. xuthus to these predators visiting patches of young citrus trees and by observing behavior of the predators in the patches. The result showed that the chemical defence is not effective against the tree sparrow, but that about 40% of the attacks of the paper wasp end in failure because of the chemical defence. It also showed that when females of the paper wasp encounter the prey, some of these predators rarely attack them, but, instead, wait to share the prey killed by females showing effective capturing skill.

**R9.4.**  
**5** THE DEFENSIVE SYSTEM OF THE ZYGAENIDAE (LEPIDOPTERA)

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Larvae of Zygaena FABRICIUS, 1775 ('burnet moth') and some related genera store a viscous secretion in highly specialised cuticular cavities. From here it is released on aggression and reabsorbed in these cavities when the aggressive situation is over. This secretion - as well as the imago itself and the larva - contains the cyanoglucosides linamarin and lotaustralin, but does not release cyanic acid, although the larvae body fluid contains  $\beta$ -cyanoglucosidases. Further components of the secretion are shown to be  $\beta$ -cyanoalanine and a complex matrix of proteins, beside water. The reaction of a number predators has been tested on the different compounds.  $\beta$ -Cyanoalanine is supposed to be the major intermediary product in the cyanide metabolism of the Zygaenidae. Thus it seems to follow the same pathway in cyanide metabolism as in plants. This also applies to the biological significance of an highly aposematic pattern, which is morphologically connected with the storage system of the secretion.

## R9.5. 1 MATING STRATEGIES IN DRAGONFLIES

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Male and female dragonflies meet at distinct places for mating, usually at rivers or ponds where the females deposit their eggs. The problem examined is how a dragonfly male searches for females such as to maximize his chances of meeting a receptive female, whilst at the same time minimizing competition with other males.

Field studies revealed that in dragonflies there exist different modes of partitioning the mating place by intraspecific aggression, e.g. spatial partitioning (territorial behaviour) and temporal partitioning; these are correlated with different ecological situations. In simulation experiments based on field data the mating success of males searching with different strategies was examined. The results indicate that it depends on the spatial structure of the mating place and on the behaviour and the number of competitors which searching strategy is optimal.

## R9.5. 2 SEXUAL RECEPTIVITY OF MATED FEMALES OF THE AUSTRALIAN SHEEP BLOWFLY LUCILIA CUPRINA

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As part of a more comprehensive study of factors affecting sexual receptivity of females of Lucilia cuprina, an investigation has been made on the likelihood that a female will mate a second time.

In a standard test for receptivity, less than 3 per cent of females mated on the day after their initial mating, but about 25% of females mated after 15 days, during which they were given no opportunity to lay. About one third of females mated when challenged on the day following the laying of their first, second or third egg masses (this fly displays distinct ovarian cycles). However, on each occasion when females were given the opportunity to lay, some failed to do so. These females were found to be highly receptive.

Injection of male accessory gland extracts into unmated gravid females markedly reduced the proportion of females that mated and increased the proportion that laid. These findings suggest that the female monitors a store of male accessory gland secretion to determine both her readiness to mate and readiness to lay.

R9.5.  
3

### SWARMING BY MOSQUITOS, A FURTHER LOOK

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Swarming by mosquitos is regarded as an activity serving to enhance random mating by representatives of asynchronously emerging subdemes. Localization is brought about by the attraction to a specific marker; synchronization is ensured by the simultaneous opening of the circadian gate. Localization and synchronization are independent of each other but together result in an enormous enrichment of the scope for genetic recombination. With this interpretation it is illuminating to fit swarming into the picture of activity shown by unfed mosquitos during the first 3 days of adult life, using the recently described diuresis curve as a background indicating physiological activity.

R9.5.  
4

### INTRASEXUAL COMPETITION IN A SPECIES OF COCCINELLIDAE (COLEOPTERA).

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The reproductive behaviour in *Illeis (Leptotheca) galbula* (Mulsant) (Coccinellidae) has been studied. Male attraction to and guarding of a female pupa for up to five days is associated with intramale aggressive territoriality and possible take-over by rival males. Both contact and non-contact pupal guarding may occur. Pupae may accept or reject the guard male. Insemination of the virgin female beetle, approximately one hour after emergence, is preceded by fierce intramale fighting with the pupal guard male about 70% sure of winning. Prolonged copulation for up to 90 minutes, or until the female becomes non-receptive, usually prevents sperm competition before oviposition, but take-over during copulation may lead to original sperm replacement. There is no post-copulatory intramale competition or guarding. The pupal guarding behaviour is unique amongst the Coleoptera, while the teneral female mating behaviour is unique in the Coccinellidae.

**R9.5.**  
**5** FACTORS GOVERNING REPRODUCTIVE ISOLATION IN THE GENUS *YPONOMEUTA*  
(LEPIDOPTERA, YPONOMEUTIDAE).

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Reproductive isolation among sympatrically occurring moths is often considered to be based solely upon differences in the chemical composition of the sex pheromones. In the closely related species of small ermine moths of the genus *Yponomeuta* these pheromones have so much in common that other factors have to contribute as well to reach effective isolation. Among them are : differences in emergence time during the season and in the duration of the pre-oviposition period; differences in calling time during the night and selection of the same specific host plant by both sexes of one particular species prior to calling.

9

**R9.5.**  
**6** CALLING BEHAVIOUR OF THE ARMYWORM, PSEUDALETIA UNIPUNCTA (HAW.)  
(LEPIDOPTERA : NOCTUIDAE) UNDER DIFFERENT PHOTOPERIODIC REGIMES.

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The calling behaviour of virgin armyworm females was studied when held under five different photoperiodic regimes (18L:6D, 16L:8D, 14L:10D, 12L:12D and 10L:14D) at  $25 \pm .5^{\circ}\text{C}$  and  $65 \pm 5\%$  R.H.. With an increase in the length of the scotophase (i) females were older when they initiated calling for the first time, (ii) females spent more time calling each night and (iii) the time a peak calling activity occurred later into the scotophase.

In another series of experiments females, after their first night of calling, were switched on the second night from one photoperiodic regime to another. If females experienced an increase in the length of the scotophase (i.e. 16L:8D — 10L:14D) calling behaviour started later and later on successive nights. On the other hand, if there was a decrease in scotophase length (i.e. 10L:14D — 16L:8D) calling advanced. If the decrease in the scotophase was  $\geq 4$  h the majority of females did not call the first night after the transfer but on subsequent nights progressively adjusted to the new photoperiodic conditions.

These results will be discussed within the context of mating success and the population dynamics of this sporadic pest species.

**R9.5.** MATING AND PHEROMONAL ACTIVITY IN PLUSIA GAMMA AND  
**7** AMATHES C-NIGRUM (LEPIDOPTERA:NOCTUIDAE)

TOMESCU, N., et al., Univ. "Babes-Bolyai", Department of Biology,  
Cluj-Napoca, ROMANIA

Adults of both species emerge sexually immature and do not exhibit a mating behaviour during 3-4 days after which the first mature individuals can be observed. The optimum age of mating is 6-8 days for P.gamma and 5-7 days for A.c-nigrum, and it corresponds to the optimum period of the release of the sexual pheromone by the females and to the maximum response of the males. Mating activity in P.gamma occurs at two hours from the beginning of the scotophase and reaches the peak after an hour. It decreases suddenly after four hours and a half. In A.c-nigrum mating activity reaches the peak six hours from the beginning of the scotophase. The usual number of matings per female is one in P.gamma, and two-three in A.c-nigrum. In both species, the feeding of the adults has a positive influence for mating and pheromonal activities. The optimum temperature is 20-25°C for P.gamma and 17-23°C for A.c-nigrum.

**R9.5.** CHEMICAL AND VISUAL CUES INVOLVED IN THE MATING BEHAVIOUR OF THE  
**8** 6-SPOTTED BURNET MOTH, ZYGAENA FILIPENDULAE L. (LEP., ZYGAENIDAE).

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By studying the mating behaviour of Zygaena filipendulae, both in the field and in the laboratory, it appears that the long-range attraction of the male is mediated by a female emitted pheromone, while close range attraction is visually directed. With regards to the Müllerian mimicry developed by these moths, the sexual isolation between Z. filipendulae and related species is discussed. Experiments with dummies have shown that the specificity of the visual attraction was low : male moths discriminate neither between 2 mimics, nor between the sexes of their own species : so it seems that the sexual isolation should be rather chemical and/or ecological. GC and GC/MS analyses of crude extracts of pheromone glands and electro-physiological data confirmed this hypothesis by showing very different pheromone secretions for Z. filipendulae and the sympatric species Z. hippocrepidis.

**S9.1.** 1 A QUARTER OF A CENTURY OF PHEROMONE RESEARCH : OPENING ADDRESS TO THE SYMPOSIUM ON "PHEROMONE TECHNIQUES" AT THE 17 th INTERNATIONAL CONGRESS OF ENTOMOLOGY, HAMBURG, AUG. 20-26, 1984

HANS E. HUMMEL

UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS 61801 - USA-

This symposium is dedicated to Butenandt and Hecker, and Karlson and Lüscher, for their pioneering contributions of 1959, when they, respectively, chemically identified the first member of the new class of biologically extremely active natural products and named them "pheromones". This occasion marks the 25 th anniversary of these two closely related events.

Research efforts in the 19th and the first half of the 20 th century are only prolegomena for the unprecedented and explosive growth of this field of chemical communication during the last quarter of a century.

Greatly refined techniques and standardized methods played a major role in this process, to the point where a clear line between the contributions of biological thought alone and its experimental realization cannot longer be drawn. Both areas are mutually supportive, a sign of growing maturity.

Insects provided in the past, and still do presently, the vast majority of examples, although other invertebrates, vertebrates and plants are becoming increasingly well investigated and understood.

Twentyfive years after Butenandt and Hecker's discovery and after Karlson and Lüscher's nomenclature proposal it is time for reflections into the past, for appreciating the present, and for looking ahead into the near future of chemical ecology.

**S9.1.1.** 1 DIRECT EVIDENCE FOR CHEMOTACTIC TURNS AT THE SEX PHEROMONE PLUME BOUNDARY IN TROGODERMA

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The behavior of male Trogoderma variabile while walking and orienting to sex pheromone was analyzed using a spherical treadmill device. Under uniform pheromone conditions, the beetles maintained an upwind menotactic orientation. A turn and local search pattern characterized the "off response" to the open-loop removal of pheromone. The beetles generated an upwind zigzag pattern in closed-loop experiments during which a computer regulated a pheromone valve to simulate the stimulus pattern of an odor plume. The zigzag pattern results directly from chemotactic on-off and off-on changes in pheromone concentration.

### S9.1.1.

2

#### ORIENTATION OF GYPSY MOTHS TO PHEROMONE: MANIPULATION OF CUES IN A WIND TUNNEL.

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Alteration in a wind tunnel of the spatial and temporal distribution of pheromone and its concentration allows direct manipulation of the cues available for orientation. The changes in the moth's flight track caused by such alterations offer clues as to what the moth perceives and the mechanisms used in orientation.

### S9.1.1.

3

#### OLFACTION IN THE BOLL WEEVIL: ELECTROPHYSIOLOGICAL AND BEHAVIORAL CORRELATIONS

JOSEPH C. DICKENS

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Electrophysiological as well as other physiological techniques were combined with laboratory bioassays to investigate the role of olfaction in the behavior of the boll weevil, *Anthonomus grandis* Boh. (Coleoptera: Curculionidae) to insect and host plant odors. The antennal olfactory responsiveness of both sexes to thirty-eight odorants was measured with electroantennogram (EAG) techniques. Similar responses were obtained from both sexes to male aggregation pheromone components (i.e. components I, II and III+IV), but females were slightly more sensitive to I. Both sexes were highly responsive to six carbon leaf alcohols. Heptaldehyde was the most active aldehyde tested. More acceptors responded to oxygenated monoterpenes than to monoterpene hydrocarbons.  $\beta$ -bisabolol, the major volatile of cotton, was the most active sesquiterpene and elicited responses equal to or greater than any other odorant tested except for heptaldehyde. In general, males, which are responsible for host selection and pheromone production, were more sensitive to plant odors tested than were females. In fact, males were as sensitive to  $\beta$ -bisabolol and heptaldehyde as to aggregation pheromone components. EAGs to sundry odorants varied with the physiological state of the insect. Electrophysiological data correlated well with behavioral experiments utilizing a new laboratory bioassay. The results are discussed with regard to a model for host selection, aggregation, colonization and dispersal by the boll weevil.

**59.1.1.** THE TANDEM GAS CHROMATOGRAPHY-BEHAVIOR BIOASSAY (t-GLC-BB) METHOD FOR  
**4** QUANTITATIVE ANALYSIS OF INSECT PHEROMONE MIXTURES AT THE LOW NANOGRAM  
LEVEL .

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2011 Cureton, Urbana, Illinois 61801 - U S A -

New detection techniques emerging during the past 2 decades increased the qualitative detectability and quantitative determination of pheromones by several orders of magnitude. The flame ionization detector (FID) introduced in 1958 launched GLC into its dominant role. Likewise, the use of whole insects (Flaschenträger, 1957) or their isolated antennae (D. Schneider, 1957) as specific biological detectors provided alternative, specific assay methods for the analysis of complex mixtures. - Combining the sensitivity of GLC-FID with the specificity of BB techniques, Anders and Bayer (1959), Feeny (1962), and Gaston et al. (1966) independently developed the versatile t-GLC-BB method. This paper describes a substantially improved version and new applications. - The test chamber for monitoring insect activation (optionally short distance orientation) consists of inexpensive metal-, glass-, and teflon parts. It can be easily disassembled, cleaned and used for repeated tests of extremely active sex pheromones at the low nanogram level with minimal carryover of residual activity. It can serve as a simple tool for labs without a flight tunnel or with a need for an assay method at the organismic level that fills the gap between electroantennogram and field bioassays. - In unknown pheromone mixtures both the number of components, their C-number and their functional groups can be determined on-line prior to isolation. Examples from Pectinophora gossypiella, Bombyx mori, and Diabrotica undecimpunctata howardi are presented. - The same principle, with HPLC as the analytical separation step, is also applicable to aquatic systems.

**59.1.1.** NEW TECHNIQUES USED IN STUDIES ON INSECT CHEMICAL COMMUNICATION  
**5**

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Multicomponent semiochemical systems are being increasingly implicated in insect communication. In studies on such systems it is necessary to collect, characterise and establish the biological activity of very complex mixtures of volatile substances produced by insects and plant hosts. Work of this nature is facilitated by the use of coupled physicochemical and electrophysiological techniques.

In this Paper, research on multicomponent semiochemical systems in some Coleoptera will be described which will illustrate the use of these techniques.



**S9.1.1.** SEX PHEROMONES AND REPRODUCTIVE ISOLATION IN FOUR SYMPATRIC  
**6** SMALL ERMINE MOTHS (LEPIDOPTERA, YPONOMEUTIDAE)

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Reproductive isolation among four sympatric small ermine moths (Yponomeuta) is analysed in terms of niches in the sexual communication channel. Potential pheromone components were identified from pheromone gland secretions of Y. evonymellus, Y. padellus, Y. cagnagellus and Y. vigintipunctatus by gas chromatography with flameionisation and electroantennographic detection. The species were found to share (Z)-11-tetradecenyl acetate (Z11-14:OAc) in combination with varying proportions of the E-isomer as primary sex pheromone components. Niche separation was achieved in additional chemical (secondary components) and temporal niche dimensions. The closely related species have different sex pheromones, while the more distant relatives Y. vigintipunctatus and Y. evonymellus seem to have identical sex pheromones, i.e. Z11-14:OAc (+20% E) and (Z)-11-tetradecenol. Our interpretation is that this should have been the sex pheromone of the ancestor of today's Yponomeuta species.

**S9.1.1.** TECHNIQUES FOR THE ANALYSIS OF  
**7** CHIRAL INSECT PHEROMONES

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The significance of chirality in pheromone perception has been clarified to a considerable extent during the past decade. Methods for determining absolute configuration and optical purity of chiral pheromones will be reviewed. They include both (i) NMR methods using chiral shift reagents, Mosher's ester, or chiral solvating reagents, and (ii) GLC and HPLC methods either on achiral or on chiral stationary phases.

### S9.1.1.

8

#### "CLOSED-LOOP-STRIPPING" A VERSATILE TOOL IN PHEROMONE RESEARCH

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Mild and non-destructive methods of removal of volatiles from living organisms combined with a suitable sample treatment and enrichment of compounds are a crucial point in natural product chemistry.

Of all known extractive procedures the "Closed-Loop-Stripping" of Grob and Zürcher [J. Chromatogr. 117, 285 (1976)] is the most promising, since only air, circulating in a closed system, is used to blow off volatile products and to transport them to an adsorbent charcoal pad. Living organisms can be enclosed in such a system without affecting their vital functions, if appropriate environmental conditions are attained.

The stripping unit consists of a circulation vessel, a stainless steel membrane pump and an all-glass filter-housing with an integrated heating coil. A removable glass-liner containing 1.5 mg of activated carbon placed in the filter-housing serves as the adsorbent trap. After stripping the total amount of retained compounds is extrated with 20 µl of a suitable solvent and can be immediately used for GC-MS analysis. Chemical micromanipulations are possible (e.g. hydrogenations) and give additional information on the nature of the adsorbed compounds.

Several practical applications in the field of pheromone research will be presented.

### S9.1.1.

9

#### MASS SPECTROMETRY OF SPIROACETALS AND RELATED COMPOUNDS AND THEIR USE FOR IDENTIFICATION OF NEW INSECT PHEROMONES

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As insects of different orders seem to produce and use very similar compounds for the transmission of various messages, basic investigations on the mass spectrometric fragmentation pattern of different classes of compounds have been carried out to facilitate the identification of respective substances from biological material by GC/MS.

We identified spiroacetals, hydroxyspiroacetals, dihydropyranes, dihydrofuranes, unsaturated methylcarbinols and respective ketones from insects of different orders. These compounds which all show unbranched carbon skeletons are believed to be biogenetically very closely related to pheromones originating from the acetate pool.

The biological activity of spiroacetals covers a broad spectrum ranging from scent marks in solitary bees to aggregation pheromones of bark beetles and sex pheromones of olive flies.

### 59.1.1. CONTROLLED-RELEASE SYSTEMS FOR THE DELIVERY OF INSECT PHEROMONES

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Insect sex attractant pheromones are volatile compounds that must be formulated in controlled-release systems to maintain prolonged biological effectiveness in field programs. Without such formulation, the chemical would need to be replenished at frequent intervals. Many controlled-release systems have been developed over the past 10 years for use as dispensers in traps or as sprays for mating disruption programs. For such formulations to be effective, the chemical nature of the pheromone (volatility, polarity, susceptibility to degradation, etc.) and the environmental conditions under which it is to be used must be considered. Formulations and their use in field programs for the gypsy moth, citrus and Comstock mealybugs, oriental fruit moth, peachtree borers, and other insects will be discussed.

### 59.1.1. MANIPULATING PHEROMONAL ACTION: ANALOGUES AND PROPHEROMONES

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Structural analogues of pheromones are generally less active than the parent compound but can be more stable and have physical properties more appropriate for field use. However, for (E)- $\beta$ -farnesene, the aphid alarm pheromone, activity was maintained when particular hydrogens were replaced by fluorine though with loss of stability.

Propheromones are prepared that release the pheromone under field conditions by the influence of sunlight, moisture or temperature. When a satisfactory release mechanism has been established, for example photorelease of pheromonal aldehydes from their adducts with nitrophenylene glycols, minor alterations to the molecule can lead to release characteristics suitable for particular field situations.

Studies on analogues and propheromones are leading to a better understanding of structure/activity relationships in behaviour controlling chemicals and have even given rise to compounds with modes of action which differ from those of the parent compounds.

## 59.1.1. PHEROMONE DISPERSAL IN THE FIELD AND ITS EFFECTS ON ORIENTATION

### 12 BEHAVIOUR - IMPLICATIONS FOR PEST CONTROL.

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A.R. GREENWAY<sup>1</sup> 1. Rothamsted Experimental Station, Harpenden, Herts, U.K.

The successful use of insect pheromones in pest control, for monitoring population movements or as direct control agents, depends in the longterm on detailed knowledge of each pest's behavioural responses to artificial pheromonal stimuli in the field. The simplest stimulus is a single, continuously emitting, point source - e.g. a trap.

Experiments with simple configurations of traps for the pea moth, Cydia nigricana (F.), have indicated the range of attraction and flight behaviour of responding moths. The effect of the uptake of sex-attractant and its subsequent release by the vegetation around a trap on the behaviour of moths has also been demonstrated.

The results indicate that: i) in wheat, a trap generates a continuous zone of attractant downwind, partly as a result of uptake by plants; ii) the range of attraction can be several hundred metres; iii) moth orientation to a trap can be disrupted by the presence of other attractant sources, but iv) some moths always orient successfully to a trap, even when surrounded by attractant from other sources.

9

## 59.1.1. MULTICOMPONENTAL SEX PHEROMONE SIGNAL: SPATIAL

### 13 DISTRIBUTION OF COMPONENTS

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The data obtained on sex pheromone emission rate and sensitivity to single components in Lepidoptera were used to determine the ratio for long axes ( $X_{\max}$ ) of zones, formed by different components. It was found that pheromone signal of Argyrotaea velutinana consists of 3 zones. The least extended zone is formed by odour of dodecyl acetate, the middle one - by E-11-tetradecenyl acetate (E-11-TDA) and the most extended one - by Z-11-tetradecenyl acetate (Z-11-TDA). The ratio of long axes for these zones approximately equals to 1:13:623. Spatial distribution of zones in 3 pheromonal strains of Ostrinia nubilalis differs greatly. The ratio of  $X_{\max}$  for zones formed by the components Z-11-TDA and E-11-TDA is approximately the following: 2.3:1; 1:32.3 and 1:2 in strains emitting Z/E TDA in proportions 97:3; 3:97 and 36:65, respectively. Pheromone signal in female of Bombyx mori consists of 2 zones. The more extended one is formed by E-10,Z-12-hexadecadienol, the less extended one - by E-10,Z-12-hexadecadienal.

The results obtained must be taken into account while working out problems of insect orientation to pheromone source.

**59.1.1.** "FOUR YEARS' EXPERIENCE WITH SYNTHETIC PHEROMONES FOR THE MONITORING  
**15** OF LITHOCOLLETIS BLANCARDELLA F. (LEPIDOPTERA, GRACILLARIIDAE) IN THE  
NIEDERELBE FRUIT-GROWING AREA (FGR)"

G. PALM <sup>1)</sup> and G. BURGHARDT <sup>2)</sup>

<sup>1)</sup> Obstbauversuchsanstalt Jork and <sup>2)</sup> HOECHST AG, Frankfurt/Main

Gradation of *Lithocolletis blancardella* occurred in that area in the period 1976 to 1981. Investigations of the population dynamics with the aid of pheromones were, among others, the basis for control at the right time at ten different locations during a four-year period. An attempt was made to establish correlations between different pheromone concentrations and the catches or the degree of infestation. An additional question was answered concerning the necessity for a bait change during a growing season.

**59.1.1.** PHEROMONES FOR CONTROL OF COTTON PESTS  
**16**

CAMPION, D.G.

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Large scale mating disruption trials for the control of the pink bollworm Pectinophora gossypiella have been undertaken using several slow release pheromone formulations. Small-scale trials have been conducted using pheromones for control of the red bollworm Diparopsis castanea, the spiny bollworm Earias insulana, Heliothis spp. & Spodoptera spp.

Mass trapping trials have also been attempted for the control of Earias, Pectinophora & Spodoptera.

The relative success of pheromone usage for the cotton pest complex is reviewed so as to highlight possible constraints & limitations of the technique & to focus on likely future goals.

**59.1.1.** EVALUATION OF PHEROMONE CATCHES OF THE NUN MOTH, *LYMANTRIA MONACHA* L.  
**17** IN HETEROGENEOUS HABITATS.

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In 1980-83 the flight activity, abundance and density of male nun moths (*Lymantria monacha*) were recorded in Danish forest stands by means of disparlure baited pheromone traps placed in trap systems ranging from single traps to 10 x 10 grids. In years with long periods of warm and dry weather the relation between male catches in pheromone traps and the number of females present was poor, leading to overestimations of population indices. In other years when male flight terminated early due to cold and rainy weather a better/coincidence was found. The Danish forest structure is very often a mixture of stands of different tree species, viz. a mosaic of breeding and non-breeding habitats of the nun moth. However, pheromone traps caught male moths in breeding as well as in non-breeding habitats. Accordingly, in good breeding habitats a dilution of males occurs resulting in smaller pheromone trap catches than expected. In poor breeding habitats pheromone traps catch more males than expected.

**59.1.1.** COMMUNICATION DISRUPTION OF *DIABROTICA UNDECIMPUNCTATA HOWARDI* AND *D. virgifera* BEETLES WITH THEIR SEX PHEROMONES IN NON-CUCURBITACEOUS CROPS.  
**18**

HANS E. HUMMEL

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Experience from the summers of 1982 and 1983 indicates the feasibility of mating communication disruption by air permeation with synthetic sex pheromones in two Chrysomelid beetle species : *D. undecimpunctata howardi* (southern corn rootworm, spotted cucumber beetle, SCR) and *D. virgifera* (western corn rootworm, WCR) . Males are unable to locate pheromone-or virgin female-baited traps in fields of *Zea mays* permeated with 10-methyl-2-tridecanone, and 8-methyl-2-decane-ol propionate, respectively. Males in unpermeated control plots have no difficulty in orienting toward pheromone sources at close range (up to 10 m) and reaching them.

Disruption experiments were performed with 8 x 8 hollow cellulose fibers attached to plants in 100 m<sup>2</sup> plots. At 4 mg of pheromone / fiber, about 90 % of disruption was observed for the initial period of several days. As the potency of the sources decreased with a half life of about 10 days, an asymptotic decline of the disruption effect occurred until control and treatments were statistically indistinguishable after one month. Thus, the disruption effect is reversible indicating the environmental benignity of the treatment. By extrapolation, about 200 grams of the SCR pheromone /ha/4 months growing season would largely disrupt mating communication in *Z. mays* fields. In *Glycine max.* located in the immediate vicinity, disruption was comparable to *Z. mays* fields, while in adjacent *Cucurbita* fields inconsistent disruption results were obtained. Secondary compounds contained in *Cucurbita* may act as natural disruptants (Hummel and Andersen, 1982, Proc. 5th Int. Congr. Plant-Insect-Relationships, Pudoc, Wageningen, p.163).

**S9.1.2.** BIOCHEMICAL INTERMEDIATES AND THEIR  
**1** RELATIONSHIP TO SEX PHEROMONE COMPONENTS

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Many lepidopteran sex pheromone components have been found to be biosynthesized from palmitic, oleic, linoleic, or linolenic acyl intermediates via various combinations of chain shortening, chain elongation, and delta-11 desaturase reactions. Conversion of the acyl intermediates to methyl esters through base methanolysis enables one to analyze for the precursor acyl compounds on capillary GLC. The presence of a particular series of intermediate acids can suggest potential pheromone components used in trace quantities. Knowledge of the various biosynthetic pathways used for pheromone production also is helpful in understanding evolutionary trends within the Lepidoptera.

**S9.1.2.** STRUCTURE ACTIVITY RELATIONSHIPS AND MODE OF OPERATION  
**2** OF INSECT PHEROMONES

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Structure Activity Relationship leads to the conclusion that pheromones are flexibly inserted into the receptor region of dendritic membranes of sensillas, thus resulting in a release of excitation. During this process diverse molecular sections of the signal substance have different significance. It is postulated that the impulse sequences coming from various nerve cells were modulated in the central nervous system and compared with inborn behavioral patterns. With this working hypothesis many results of field experiments can be explained. The theory opens new perspectives in plant protection based on pheromone inhibitors. The electroantennogram (EAG) amplitudes are dependent on the temperature, the temperature function having a hysteresis-like shape.

## 59.1.2.

3

### BIOSYNTHESIS OF BOMBYKOL

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Biosynthesis of bombykol (E)-10, (Z)-12-hexadecadienol, sex pheromone of female silkworm moth, was investigated using various kinds of deuterium labeled its possible precursors, (Z)-11-hexadecenoic acid {(Z)-11-HDA} and (E)-10, (Z)-12-hexadecadienoic acid (bombyk acid). These two components had been identified by us as characteristic fatty acids in the pheromone gland of its pupa and moth.

(A) 11d, 12d-(Z)-11-HDA  $\xrightarrow{\quad\quad\quad}$  d2-bombykol, d2-bombykol (E,E-isomer)  
 $\xrightarrow{\quad\quad\quad}$  d2-bombyk acid

11d, 12d-(Z)-11-HDA was applied topically on the pheromone gland of the pupae two day before emergence and after emergence the pheromone gland components of adult moths were examined using capillary GC-MS. d2-Bombykol, its E,E-isomer and d2-bombyk acid were identified by their retention time and characteristic ions.

(B) 9,9 d2-Bombyk acid  $\xrightarrow{\quad\quad\quad}$  d2-bombykol.

9,9 d2-Bombyk acid was applied and examined on a same way as (A) and d2-bombykol was identified.

(C) We are investigating a mechanism of conjugated double bond biosynthesis from (Z)-11-HDA. Three d-labeled (Z)-11-HDAs, 4,4d2, 10, 10d2-(Z)-11-HDA, 4,4d2-13, 13d2-(Z)-11-HDA and 4,4d2, 10, 10d2, 13, 13d2-(Z)-11-HDA were also applied on the pupal pheromone gland. Number of deuterium present in the mass spectrum of the bombyk acid and bombykol will give us good suggestions about it.

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## 59.1.2.

4

### INSECT PHEROMONE RECEPTION: A DYNAMIC KINETIC EQUILIBRIUM.

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Male moths seek out a sexually receptive female by flying in a zig-zag manner along her pheromone plume. In this pheromone-elicited orientation behavior, these moths display concentration- and time-dependent responses that appear to be governed by the biochemical properties of their sensory hairs. In an attempt to understand how these sensory hairs process information, we have studied proteins which are unique to these hairs, focusing on how protein-pheromone interactions might influence the animals' behavior. These proteins include a pheromone degrading esterase and a pheromone binding protein. The results of this work have led to a molecular model which suggests that pheromone reception involves a dynamic kinetic equilibrium system, rather than one-step-at-a-time processing. In this model there are three major pathways for pheromone: pore-tubule to binding protein to receptor to esterase; pore-tubule to binding protein to esterase; and pore-tubule to esterase. Both data and the model suggest that as pheromone concentration increases, an increasing proportion of pheromone is shunted directly to the esterase, bypassing the receptor and thus preventing receptor saturation. This model offers a mechanism to explain the exceptionally broad stimulus-response range these animals show, and as such suggests a molecular model of how shifting equilibria within a sensory hair can affect behavior.

Supported by NSF PCM 80-11152, RGV supported by NRSA GM07270 & GM07108.



**59.1.2.** PHEROMONE RESPONSE, ENZYMATIC ACTIVITY AND ELECTROPHORETIC PROPERTIES  
**5** OF ANTENNAL ESTERASE OF MALE DIAMOND-BACK MOTH IN TAIWAN

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Natural populations of diamond-back moth (Plutella xylostella L.) collected from five different vegetable fields were investigated. The response of male to the female pheromone was revealed by a Y-test in laboratory and mass trapping of adult males in field as well. The antennal esterase activity of diamond-back moth was monitored by either 1-naphthylacetate or C<sup>14</sup> (Z)-11-hexadecenyl acetate. In addition the zymogram of antennal esterase was also studied by poly-acrylamide gel electrophoresis. We found that variations of pheromone response of the adult male to trinary of (Z)-11-hexadecenal, (Z)-11-hexadecenyl acetate, and (Z)-11-hexadecen-1-ol, was either age-dependent or population-dependent. Assay of antennal esterase activity was positively correlated with the behavior of the male moth. Zymogram of antennal esterase showed that there are three to six bands varied with different population. Certain bands are possibly associated with the response of male adults to pheromone. The pheromone hydrolytic activity of antennal esterase by using isotope labeled acetate pheromone was shown to be significantly high when the male adapted to the habitat where the insecticide was intensively used for pest control.

**59.1.2.** PHYSIOLOGICAL CONTROL OF PHEROMONE EMISSION OF THE GYPSY MOTH,  
**6** LYMANTRIA DISPAR (L.)

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The female gypsy moth, Lymantria dispar (L.) is used to study the neural and endocrine control of the onset of calling behavior and the emission of sex pheromone. The study begins with the localization and identification of the pheromone glands on the intersegmental membrane between 8th and 9th abdominal segments. Ablation experiments revealed that the removal of corpora cardiaca, corpora allata and ovaries did not interrupt calling and pheromone emission. Nerve severance experiments revealed that the removal of brain, severance of circumesophageal connectives and severance of connectives anterior to the terminal abdominal ganglion had no adverse effect on calling but seriously curtailed pheromone emission. In contrast, surgical experiments also revealed that the removal of terminal abdominal ganglion or just the severance of nerves posterior to the ganglion would effectively eliminate both calling and pheromone emission. Electrophysiological recordings, from the last pair of nerves of the terminal abdominal ganglion, revealed different firing patterns from calling and non-calling females. To minimize possible traumatic effects of the various surgeries, individuals used in the study were operated on in either larval or pupal stage. Pheromone emission by individual moth was determined by either a male wing fanning bioassay or a gas chromatographic analysis.

**59.1.2.** SYNTHESIS AND BIOACTIVITY OF (Z)-13-HEXADECEN-11-YN-1-YL ACETATE, THE PROPOSED SEX PHEROMONE OF THAUMETOPOEA PITYOCAMPA, AND OF ITS (E)-STEREISOMER.

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(1) Istituto di Chimica organica; (2) Istituto di Entomologia agraria - Università di Pisa - Italy.

The compounds were prepared according to a general method which we have developed for the stereospecific or the stereoselective synthesis of conjugated diunsaturated compounds. Field tests showed that traps baited with the single compounds or with their mixtures were highly effective for males of Thaumetopoea pityocampa in addition to the ones of Ocnerostoma sp..

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**59.1.2.** TAXONOMIC VALUE OF THE CHEMICAL COMPOSITION OF THE SEX PHEROMONE BLENDS IN ARCTIID MOTHS AND RELATED FAMILIES.

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All the Arctiid moths of the subfamily Arctiinae use derivatives of linoleic and linolenic acids as key compounds of their sex pheromone blends. According to the chemical structure of these derivatives, three groups can be distinguished in this subfamily using either polyenic hydrocarbons, either ethylenic epoxides or blends of these two molecular features. Such chemiotaxonomic relationships can be found also in the two others Arctiidae subfamilies : Lithosiinae and Callimorphinae. Neotropical Ctenuchidae seem more related to Arctiidae than the European and paleotropical species and according to some taxonomists, revision of the family Ctenuchidae must be undertaken.

S9.1.2.  
10

SEX PHEROMONE BLENDS OF SOME EUROPEAN TORTRICIDS

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Female sex gland constituents of Adoxophyes orana, Archips rosanus, Cydia pomonella, Eupoecilia ambiguella, Grapholitha funebrana and Lobesia botrana were characterised by means of gas chromatography linked with mass spectrometry and electroantennographic detection. All species contained several chemicals related to the known sex pheromone components, the total blend comprising up to twelve constituents in the case of the codling moth. Supplementing the previously employed field formulations with these additional compounds led to better male attraction in some cases and higher specificity in others.

S9.1.2.  
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VARIATION BETWEEN INDIVIDUAL EPHESTIA CAUTELLA FEMALES IN THE COMPOSITION OF THE SEX PHEROMONE BLEND.

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The composition of the pheromone blend released during calling by single females of Ephestia cautella has been monitored in a laboratory strain. The relative proportions of the two identified components of the blend (ZETA and ZTA) vary over an unexpectedly wide range (range of ZETA:ZTA was 58:42 - 98:2) and in a manner such that the mean blend of the population (88:12) differs markedly from published population means for the same species. The compositions of blends in several field strains are being sampled, therefore, to indicate whether or not this wide range of interindividual variation results from a loosening of selection pressures in the laboratory environment. Preliminary samples provide evidence of ranges of interindividual variation similar to the laboratory strain. Some biological implications of these results are briefly considered.

59.1.2.  
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## IDENTIFICATION OF SEX PHEROMONE COMPONENTS OF THE CIGARETTE BEETLE LASIODERMA SERRICORNE

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Comprehensive investigation of female-produced sex pheromone components of the cigarette beetle was carried out. Seven sex pheromone components were isolated and their structures were elucidated to be 4,6-dimethyl-7-hydroxy-nonan-3-one(serricornin), 3,4-dihydro-2,6-diethyl-3,5-dimethyl-2H-pyran (anhydroserricornin), 4,6-dimethyl-nonan-3,7-dione, 4,6-dimethyl-nonan-3,7-diol, 4,6-dimethyl-7-hydroxy-4E-nonen-3-one, 2,3-dihydro-3,5-dimethyl-2-ethyl-6-(1-methyl-2-oxobutyl)-4H-pyran-4-one(serricorone) and 2,3-dihydro-3,5-dimethyl-2-ethyl-6-(1-methyl-2-hydroxybutyl)-4H-pyran-4-one(serricorole) by spectroscopic evidence and their syntheses. The structural similarities of these components such as the positions of methyl-branches and functional groups, and the stereochemistry of their molecule, lead us to an assumption that these components were derived from common polyketide precursors having four or five propionic acid units. Up to present, several insect behaviour regulators which seem to be related to the polyketide biosynthesis, were isolated as sex pheromone(*Stegobium paniceum*), aggregation pheromone(*Scolytus multistriatus*), alarm pheromone(*Atta* ants, *Manica munica*) and defensive substance (*Dasymutilla occidentalis*, some *Opiliones*). Judging from the wide existence of these compounds, the polyketide biosynthesis might be closely related to the formation of the insect pheromone and other behaviour regulators.

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59.1.2.  
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## CHEMICAL COMMUNICATION IN DUNG BEETLES (SCARABAEINAE)

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Mature males of a number of species in the genus *Kheper* produce a white flocculent substance from pores in a depression on either side of the first abdominal sternite. This material emerges from the pores as hollow, layered tubules impregnated with minute quantities of the volatile pheromone in which hexadecanoic acid, 2,6-dimethyl-2-heptenoic acid and nerolidol are the major constituents. The white secretion is brushed into the air by brushes on the tibiae of the hind legs in order to enlist the co-operation of a female in moulding and rolling a brood ball. The solid white material was found to have a polypeptide structure consisting of fifteen amino acids. A synthetic mixture of the major volatile components of the secretion was found to have a deterrent effect on male dung beetles. So far no attraction of females by this mixture could be demonstrated. An investigation of the minor components in the secretion and a quantitative comparison of the composition of the volatile material in the secretions of different *Kheper* species have therefore been carried out.

The detection of fresh dung by dung beetles plays an extremely important role in areas with an intact ecology. Normally, in such areas fresh dung is located by dung beetles within a few seconds. Methods for the identification of the dung beetle attracting kairomore will be discussed.

**S9.1.2.** CHEMICAL AND BIOLOGICAL STUDIES OF THE AGGREGATION PHEROMONE OF THE  
**14** GREATER GRAIN BORER, *PROSTEPHANUS TRUNCATUS* (COLEOPTERA: BOSTRICHIDAE)  
D.R. HALL<sup>1</sup>, A. CORK<sup>1</sup> and R.J. HODGES<sup>2</sup>  
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The greater grain borer, *Prostephanus truncatus* (Coleoptera: Bostrichidae), has recently been introduced into Tanzania and has become a serious pest of stored products, particularly maize. An aggregation pheromone produced by the male beetles has been detected by electroantennography linked to gas chromatography, and identified by mass spectrometry and comparison with synthetic materials. The biological activities of the major pheromone component and a range of isomers and related compounds have been compared by electroantennography and a laboratory bioassay.

**S9.1.2.** ISOLATION AND IDENTIFICATION OF AGGREGATION PHEROMONES OF  
**15** CUCUJID GRAIN BEETLES

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The volatiles of five species of feeding cucujid grain beetles in the genera Cryptolestes and Oryzaephilus were captured on Porapak Q. Volatiles of each species were attractive to both sexes of the species, as determined by arena olfactometer and pitfall bioassays. HPLC and GLPC fractionation of the volatiles yielded microgram amounts of attractants. Mass, n.m.r. and infra-red spectra were used to determine that the attractants were a new class of macrolide pheromones. A total of seven different aggregation pheromones were identified for C. ferrugineus, C. pusillus, C. turcicus, O. mercator and O. surinamensis. The latter species utilizes a combination consisting of three macrolide aggregation pheromones, whereas the remaining species utilize two macrolides each.

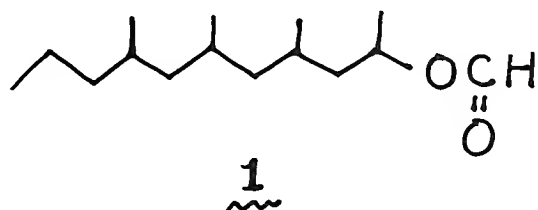
59.1.2.  
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# SYNTHETIC APPROACHES TO THE DETERMINATION OF THE ABSOLUTE CONFIGURATION OF LARDOLURE

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Aggregation pheromone of the acarid mite, Lardoglyphus konoi Sasa and Asanuma (Acarina : Acaridae), was shown to be 4,6,8-trimethyl-2-undecanol formate 1 by Y.Kuwahara, et al [Agric. Biol. Chem., 46, 2283 (1982)]. To determine the relative and absolute stereochemistry of 1 with four chiral centers, various attempts were made to achieve partially or totally stereocontrolled syntheses. A highly stereocontrolled synthesis of the natural and optically active pheromone itself will be disclosed.



59.1.2.  
17 ASYMMETRIC SYNTHESIS OF INSECT SEMIOCHEMICALS--  
SELECTED STRATEGIES

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A variety of general methods are available to the organic chemist seeking to synthesize natural products stereoselectively. Most of these have been employed in the cause of insect sex pheromone synthesis. A tabulation of the methods by type will be presented with exemplification as will a brief discussion of the advantages and disadvantages of each approach. Some adaptations based on these general methods will then be presented with reference to the syntheses of several insect semiochemicals that have been identified by the USDA.

**59.1.2.** STEREOCONTROLLED SYNTHESSES OF CHIRAL AND ACHIRAL TERPENOID  
**18** ALLOMONES AND PHEROMONE COMPONENTS.

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Istituto di Chimica Organica- Via Risorgimento 35-56100 Pisa-ITALY

The 2-substituted 1,3-butadienyl moiety is present in some chiral and achiral terpenoid allomones and pheromone components.

We have developed simple and convenient routes for the stereo- and regio controlled synthesis of such compounds.

Results in this area will be presented.

**59.1.2.** THE PHEROMONAL BASES FOR CHEMISOCIALITY IN THE HYMENOPTERA  
**19**

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Ants and eusocial bees have evolved communicative systems that are predicated on the evolution of idiosyncratic pheromonal blends. Distinctive natural products fortify their secretions and chemical signals may be based on the programmed responsiveness of these arthropods to selected compounds that are often very limited in their hymenopterous distribution. Alarm pheromones often serve admirably as paradigms of the pheromonal specificity that characterizes the volatile information-bearing exudates evolved by hymenopterans.

9.1.2. 20 ON THE CHEMISTRY OF QUEENNESS: THE MANDIBULAR GLAND SECRETIONS  
OF THE CAPE HONEYBEE, *APIS MELLIFERA CAPENSIS*.

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The free fatty acid composition of the mandibular gland secretions of virgin queens, mated queens and workers of Cape honeybees have been analysed by means of a sensitive capillary gas chromatographic technique. The composition of the secretion has been found to be variable, with the variability being dependant on both social conditions and age.

The rearing of workers under queenless conditions has indicated that *capensis* "false" queens are producing mandibular gland secretions that are clearly queen-like in their compositions.

The implications of these discoveries for pheromonal control of social relationships in this eusocial insect are considered.

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9.1.2. 21 ATTRACTIVITY OF MANDIBULAR GLAND SCENTS TO MALE PRIMITIVE BEES

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The attractivity of male and female cephalic secretions to males during their mate-seeking behaviour was tested in the field. The seven species studied represent 3 different families of primitive bees, - Colletidae, Andrenidae and Melittidae - and three different types of male strategies: mate-seeking at nest aggregations, at food flowers, and at nonresource-based sites.



**59.1.2.** COMPARISON BETWEEN MANDIBULAR GLAND SECRETIONS OF SOLITARY AND  
**22** SOCIAL BEE SPECIES

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\*) Institut für Organische Chemie der Universität Hamburg  
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Mandibular gland secretions of solitary and social bees often represent complex mixtures. However, regarding qualitative compositions, striking similarities are found between species and genera. Besides the almost ubiquitous neral/geranial, the respective alcohols and a few other terpenes, the majority of the compounds seem to originate from the acetate pool.

Hydrocarbons, methylketones, ethylketones and the respective carbinols, spiroacetals and related compounds as well as esters are used to form species- and often sexspecific blends.

"Wax-type esters" like octyloctanoate etc. which in contrast to sexpheromones of Lepidoptera carry the ester group towards the middle of the molecule seem to be very widespread among bees. Mass spectrometric characteristics of these compounds are discussed.

**59.1.2.**

**23** CHEMICAL MARKING IN TERRITORIAL BEHAVIOR OF MALE COSTA RICAN CENTRIS BEES

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Male bees of several Central American Centris species set up small territories of a few square meters area in grasslands or treetops, from which intruding insects are driven. Although patrolling and fighting are involved in maintaining these territories, chemical marking also plays a role. Some bees at the subgenus Centris deposit mandibular gland secretions on semicircular arrays of grass stems in a procedure resembling a waggle dance. Other bees from subgenus Hemisiella rub secretions from hind leg tibial glands onto special hairs on the legs and deposit the secretions on twigs and leaves. The mandibular gland secretions studied so far consist of monoterpenes while leg gland secretions are predominantly straight chain acetates and ketones.

Preliminary evidence suggests these chemically marked territories are important mating areas.

## 59.1.2. THE CHEMISTRY OF DUFOUR'S GLAND IN PRIMITIVE BEES

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We have found that the Dufour gland secretion in many genera of primitive bees are made up of esters of relatively low volatility. These compounds are mevalogenic, acetogenic or combinations thereof. Both acyclic and macrocyclic substances occur. Some conclusions regarding the function and the evolution of the Dufour gland secretion can be drawn from knowledge about its chemistry. Also, some taxonomic and systematic inferences can be made, by comparisons.

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## 59.1.2. STRUCTURAL AND COMMUNICATIVE FUNCTIONS OF DUFOUR'S GLAND SECRETION IN SOLITARY BEES.

### 25

ABRAHAM HEFETZ. DEPARTMENT OF ZOOLOGY, TEL AVIV UNIVERSITY, RAMAT AVIV, ISRAEL

In the ground dwelling bee, Proxycopa olivieri, Dufour's gland secretion is used to line the brood cells with hydrophobic layers. The secretion is composed of a series of C<sub>21</sub>-C<sub>35</sub> alkanes and alkenes. In another Xylocopini bee, the wood nesting, Xylocopa sulcatipes, Dufour's gland secretion is mostly composed of ethyl esters, of which ethyl docosanoate and ethyl tetracosanoate are dominant. In contrast to P. olivieri, X. sulcatipes does not use this secretion to line its brood cells. It is suggested that the function of Dufour's gland secretion is dependent on the bee's ecology, and may only be used to line brood cells in ground dwelling bees.

In addition to its structural function, Dufour's gland secretion has a communicative function. In the ground dwelling Eucera palestinae, the secretion, composed mostly of hydrocarbons accompanied by methyl and ethyl esters, lines the nest galleries and brood cells, and enables the bee to recognize its nest. If it is confronted with strange Dufour's gland secretion at the entrance of its own nest, a bee will hesitate before entering, but no hesitation is observed when its own secretion, or a novel odor as a control, is present at the nest entrance. There is a clear adaptive value of the existence of a specific nest odor for bees nesting in dense aggregations.

59.2.  
1

## REGULATION OF MATING BEHAVIOUR IN TSETSE FLIES

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The importance of maximum rates of insemination in female tsetse flies is emphasised in relation to their low rate of reproduction. Initial attraction between the sexes is visual, but mating behaviour persists only after stimulation of the male by long-chain hydrocarbons present in the surface cuticular waxes of the female. These "short-range" or "contact" sex pheromones are methyl branched alkanes and of seven species of Glossina studied no two share a pheromone in common. Synthetics are available and are being used to learn more of mating behaviour in the field and in the development of new control methods for tsetse.

59.2.  
2

## CHEMICAL COMMUNICATION IN TSETSE

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Electrophysiological studies have revealed that the female contact sex pheromones, morsilure and pallidilure, are not perceived by contact chemoreceptors on the legs of Glossina m. morsitans and G. pallidipes.

Electroantennogram studies indicated that these pheromones are perceived by olfactory receptors on the antennae, which was further confirmed by behavioural experiments.

Studies are in progress to determine the adequate stimuli for the contact chemoreceptor cells in the legs.

## 59.2. MALE HOUSEFLY PHEROMONES

### 3

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Two sex pheromones of Musca domestica are known to date. One, abstinon, which prevents homosexual courting, is present in the male cuticular hydrocarbons. The second is secreted from the male genital tissue and it attracts virgin females, causing an increase in their receptivity. Mating behavior of both male and female M. domestica comprise elements which could be elicited by the above or other pheromones, on close contact.

9

## 59.2. SEX PHEROMONE OF THE HOUSEFLY: BIOSYNTHESIS AND ENDOCRINE REGULATION

### 4

GARY J. BLOMQUIST, BIOCHEMISTRY DEPARTMENT, UNIVERSITY OF NEVADA, RENO, NV, U.S.A. 89557

The cuticular lipids of a number of insect species function in chemical communication. The sex pheromone of the female housefly is a modified cuticular lipid and contains (Z)-9-tricosene (muscalure), a C<sub>23</sub> epoxide and a C<sub>23</sub> ketone. These components are absent on males. The C<sub>23</sub> sex pheromone components are produced by cuticle associated abdominal cells and first appear on the surface of females at about 2 days post-emergence. Their production correlates with ecdysone levels, vitellogenesis, and ovarian maturation. When insects were ovariectomized within 6 hr of emergence, no C<sub>23</sub> sex pheromone components were produced. Implantation of ovaries or injection of 20-hydroxyecdysone into ovariectomized females restored sex pheromone production. Repeated injections of doses of 20-hydroxyecdysone as low as 50 ng/insect were effective in inducing the synthesis of the C<sub>23</sub> sex pheromone components. The implantation of developing ovaries or injection of 20-hydroxyecdysone into male houseflies also induced the production of the C<sub>23</sub> sex pheromone components, indicating that both males and females possess the capability to produce sex pheromone components but normally this ability is only expressed in vitellogenic females. (Z)-9-Tricosene is formed by the elongation of oleic acid followed by reductive decarboxylation. The C<sub>23</sub> alkene is converted to the corresponding epoxide and ketone by all major body parts of both males and females, with the highest activity observed in the legs of males.

## 59.2. AGGREGATION PHEROMONE IN DROSOPHILA VIRILIS

5

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Males of Drosophila virilis Sturtevant emit a pheromone which attracts both males and females in a "wind-tunnel" bioassay chamber. The response includes upwind flight and alighting at the pheromone source. Extracts of sexually mature males are far more active than those of younger males or females of any age. However, flies of any age and either sex respond readily to the active male extract. Sexual maturity is not a prerequisite for the response. The flies must be starved for at least several hours before the response is seen.

The pheromone has a number of components. Chromatography of the active crude extract on silica yielded 3 active fractions, with polarities of hydrocarbons, similar to ester, and greater than alcohols, respectively. The active compound in the hydrocarbon fraction was found to be Z-10-heneicosene. Progress on the other two active fractions will be reported.

## 59.2. CHEMICAL COMMUNICATION IN DROSOPHILA MELANOGASTER COURTSHIP IS MEDIATED BY CONTACT DETECTION OF CUTICULAR APHRODISIACS.

6

ANTONY Claude  
Centre de Génétique Moléculaire du C.N.R.S. - Groupe d'Enzymologie Physico-chimique - 91190 Gif-sur-Yvette - France.

The sexual behavior of Drosophila melanogaster males is triggered by female stimuli. We show that female specific chemical stimuli can induce the typical wing vibration of courting males. Using in a bioassay the time of wing vibration as a quantitative parameter of the induced response of males, we were able to isolate from the female cuticle long chain unsaturated hydrocarbons which are behaviorally active. Dose-response tests, with purified molecules, show that dienes, especially 7-11 heptacosadiene, are the most efficient molecules to initiate the courtship behavior.

Males produce an inhibitor of other males courtship, cis-vaccenyle acetate. During copulation this substance is transmitted to the female, which consequently becomes less attractive, while an inhibition of the aphrodisiac synthesis takes place.

A few mutants affected in the production of the pheromonal compounds will be described (ecd1, ap4, dsx and tra2).

Chemoreception of aphrodisiac messages appears to be mainly achieved by contact between male front legs with any part of the female body. Moreover the front legs of only males bear extra chemosensilla which might be involved in the detection.

59.2. STUDIES ON INTRASPECIFIC AND INTERSPECIFIC CONTACT CHEMICAL  
7 COMMUNICATION

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PESTICIDE RESEARCH INST., FACULTY OF AGR., KYOTO UNIVERSITY, KYOTO 606, JAPAN

1. Sex recognition in the cockroach, *Nauphoeta cinerea*.

Mature males of *Nauphoeta cinerea* raise their wings at the recognition of mature females through their antennal contacts. The wing-raising stimulants were identified in the cuticular wax of both sexes, although mature males exhibit this action to mature females much more frequently than to males. We suggested the possible presence of a male produced depressant(s) to wing-raising in the male, and this wing-raising depressant was identified in the male cuticular wax. The function of the depressant in the sex recognition is discussed.

2. Oviposition stimulants in *Ceroplastes rubens* to *Anicetus beneficus*.

Host recognition by the female *A. beneficus* (Hymenoptera: Encyrtidae) seems to start with perception of a chemical cue from the scale covering of the natural host, *Ceroplastes rubens*. Chloroform extract of the scale consists primarily of terpenoid which induce ovipositional behavior in female *A. beneficus*. The correlation of the wax composition of the genus *Ceroplastes* and its oviposition stimulation toward *A. beneficus* is discussed.

59.2. FACTORS INFLUENCING THE OVIPOSITION-DETECTING PHEROMONE OF THE ALFALFA  
8 BLITCH LEAFMINER, AGROMYZA FRONTELLA (ROND.) (DIPTERA : AGROMYZIDAE)

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Intraspecific larval competition is a common phenomenon when densities of the alfalfa blotch leafminer are high, despite the presence of an oviposition-detecting pheromone deposited on the substrate by females following oviposition. Adults resulting from such competition are frequently reduced in size. While both large and small females produced and recognised the epideictic pheromone, when all available oviposition sites had been used once, significantly more eggs were subsequently laid on leaflets marked by small females. Thus at high population densities the progeny of small females (that survived competition) will themselves have a greater probability of being subjected to larval competition than progeny of large females. Following oviposition small females marked the substrate less than large ones, suggesting differences in the pheromone quantity. This hypothesis is supported by the fact that small females fed significantly less than large females and that pheromone production is associated with feeding activity. Bioassays using large females fed on alfalfa or hop medic were also carried out using both alfalfa and hop medic as oviposition sites. Females fed on alfalfa and ovipositing on alfalfa laid significantly more eggs on leaflets marked by hop medic-fed females than on those marked by alfalfa-fed ones. However on hop medic stems, alfalfa fed females were unable to discriminate between the two pheromone "sources". Similar results were obtained using females fed on hop medic, with discrimination evident on hop medic stems but absent on alfalfa.

59.2.  
9

CONTACT PHEROMONE REGULATION OF INTRASPECIFIC COMPETITION IN  
FRUIT FLIES

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Uniform spacing of eggs by ovipositing females may be adaptively advantageous in any insect species where larvae are constrained to grow in a limiting resource. Following oviposition, the apple maggot fly, Rhagoletis pomonella, marks the egg-laying site (a growing fruit) with a contact pheromone which elicits dispersal of subsequent arriving conspecifics away from that site.

Here, we will focus on (a) the carrying capacity of a fruit for R. pomonella larvae, including fitness of adult progeny under varying larval density levels, (b) the amount of pheromone deposited on a fruit in relation to the larval carrying capacity, (c) the half-life of pheromone under varying environmental conditions and in relation to larval carrying capacity, and (d) use of a radio-labelling technique to evaluate the hypothesis that the pheromone may need to retain residual activity only long enough to provide the first larva in a fruit a headstart over subsequent larvae for a decisive competitive advantage to be gained.

59.2.  
10

VARIATION OF CUTICULAR COMPOUNDS AND INTER AND INTRA-  
SPECIFIC AGGRESSIVE BEHAVIOR IN TERMITE SPECIES OF  
THE GENUS RETICULITERMES

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Cuticular compounds discriminate species of European Termites in the genus Reticulitermes. Inter and intraspecific aggressive behavior are well correlated with quantitative and qualitative variations of alkanes, alkenes and methyl branched alkanes which make a chemical signature on the cuticle. A cinematographic analysis shows that a true contact is absolutely necessary to determine the aggressive behavior. This chemical analysis allowed us to build a phylogenetic tree and gave a good taxonomic key based on difference of cuticular compounds both in Europe and United States.

**59.2.** PHEROMONE COMMUNICATION OF Aleochara: A COMPROMISE BETWEEN  
**11** FEMALE RECOGNITION, MALE COMPETITION AND FEMALE CHOICE

K. PESCHKE

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Females of the staphylinid beetle, Aleochara curtula, produce unsaturated C21 and C23 cuticular hydrocarbons, acting as a close range aphrodisiac pheromone. The predatory beetles meet at carcasses. The females leave the carrion for egg deposition very soon after feeding and copulation, whereas the males stay at the carcass (sex ratio 70-80% males) and show conspicuous intrasexual aggression (repulsion from the resource, injuries). Under certain conditions (freshly emerged, migration from other carcasses, transfer of spermatophores, hibernation) the males produce the female sex pheromone, too. Thus they avoid aggressive responses of other males and are allowed to stay at the carrion for feeding. Contrary to this selective pressure to keep a certain level of the female sex pheromone, the females prefer males with a low titer of female sex pheromone for copulation. The fine adjustment of the pheromone level by interacting selective pressures seems to be affected by different ecological requirements of closely related species.

9

**P9.-** FLUORINATED ANALOGS OF INSECT SEX PHEROMONES  
**1**

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Several fluorinated unsaturated aliphatic acetates, analogs of the corresponding insect sex pheromones, have been prepared to study their effects on the mating communication systems of *Spodoptera littoralis*, *Diparopsis castanea*, *Laspeyresia pomonella*, *Bombyx mori*, *Prioxystus robiniae*, *Lobesia botrana*, *Grapholita molesta*, *Argyrotaenia velutinana*, *Platynota stultana*, and *Thaumetopoea pityocampa*.

Results of bioassays of some of these compounds are presented, and comparison with the luring power of the natural pheromone are discussed



Pg.-  
2

INTRA- AND INTERSPECIFIC SEX-PHEROMONE COMMUNICATION  
IN THE GENUS *YPONOMEUTA* (LEPIDOPTERA, YPONOMEUTIDAE)

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Analysis of the courtship of European small ermine moth species (*Yponomeuta*) shows differences in the behavioural patterns. Interspecific attraction and courtship of some species was found also. However, few copulations occur in the experiments because a female rejects a nonspecific male when at close distance. This suggests that male pheromones play a key role in the reproductive isolation of these species. Behavioural observations in flight tunnels reveal that long-range attraction of the moths is mainly governed by female sex pheromones.

Pg.-  
3

AN EXAMPLE OF 'PARADOXICAL ESS' OBSERVED IN SYNHOSPITALIC  
Drosophilella SPECIES

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I report the fact which is considered to be an example of 'paradoxical' ESS (Maynard Smith & Parker 1976) in asymmetric contest. The adult flies of the two synhospitalic Drosophilella species, D. alocasiae and D. xenalocasiae, which breed in the same spadix of *Alocasia odora* (Araceae), utilize only young spadices for feeding, resting, mating and ovipositing. So, it should be predicted that the intra- and/or interspecific competitions for the limited resources such as feeding or ovipositing sites are present. They congregated in a shady part of the spadix together. When an individual tried to come and invade into the group (intruder) or someone standing in the group attempted to move his or her position (rowder), the intruder or the rowder attacked the residents by pushing, body crashing or sometimes by boxing. I observed some 20 contests or more. In each case, the contest settled soon without dangerous escalation. To my surprise, the intruder or the rowder always won regardless of his or her size. It is natural that the larger individuals or residents win in the case where the severe injury is absent and the possibility of having more to gain by accepting defeat is unlikely. Thus, the result presented here should be considered as an example of 'paradoxical' ESS.

P9.-  
4 BIRDS' ATTACK ON BUTTERFLIES AND "WING DAMAGES"

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It is said that the distinctive damages on wings of butterflies and moths, symmetrical V-shaped "beak marks", are the evidence for actual attacks by birds. I examined whether such damages were inflicted only by birds' attack.

The experiment was carried out in laboratory using the butterflies of the genus Pieris as materials. The control butterflies were put in a cage and were allowed to fly freely, while the experimental butterflies were fed to caged birds (tits and warblers), then the wing damages of both samples were analyzed. Although small cracks were seen in samples of both groups, large, symmetrical injuries were present only in the samples attacked by birds. It is therefore suggested that these distinctive damages are mainly caused by birds' attack.

P9.-  
5 MECHANISM OF THE PREY FINDING BY THE APHIDOPHAGUS LADYBIRD  
BEETLE, HARMONIA AXYRIDIS PALLAS (COLEOPTERA : COCCINELLIDAE)

SHOHKO OBATA

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Adults of Harmonia axyridis with no experience in feeding aphids after emergence were attracted to the small gauze bag which contained aphid-infested leaves and was attached to the "model tree". They searched on the bag for a significantly longer time. The gauze bag containing leaves alone did not attract beetles. The transparent polyethylene bag containing leaves alone seemed to attract beetles, but the co-existence of the odor of aphids significantly enhanced its attractancy. These results suggest that adults of H. axyridis can detect aphids with the olfactory sense and the green color of leaves helps locating them.

P9.-  
6

## PROCESSES OF FEMALE SEARCHING BY MALE POTATO TUBER MOTHS

TOMOHIRO ONO

Males responding to female pheromone approached the vicinity of females by intermittent short flights. Male behavior changed to walking while wing fanning approximately 40 cm from the female. Searching by walking was characterized by increased activity and frequent turning near the female, and continued until the male contacted the female. If the first copulation attempt failed, male behavior changed to area-restricted searching. This mechanism was effective in relocating the female.

P9.-  
7

## POLLINATORS AS PREMATING ISOLATION MECHANISMS FOR SYMPATRIC OPHRYS SPECIES

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Flowers of the orchid genus *Ophrys* mimic females of certain species of bees in order to attract pollinating males by imitating copulation releasing signals. Since males react in a species-specific way, they function as premating isolation mechanisms for sympatric *Ophrys* species. In Southern Spain we could show that four sympatric forms of the taxonomically confused *O. fusca* group attract four different bee species, which belong to four different families. Therefore these *Ophrys* forms should be regarded as genuine species. The same is true for *O. fusca* agg. in Southern France and probably on Crete. The following allopatric species of the *O. fusca* group, *O. atlantica* (Southern Spain) and *O. iricolor* (Crete) and also *O. bertolonii* from Italy which does not belong to the *fusca* group display a significant optical similarity. These three species are pollinated by *Chalicodoma*. This example demonstrates that allopatric species can be pollinated by a common pollinator and that this pollinator can select for convergent similarity in unrelated species of *Ophrys*.

P9.-  
8

MORPHOPHYSIOLOGICAL STUDY OF THE GLANDS AND CHEMICAL STRUCTURE OF THE ALARM AND PIST PHEROMONES OF Liometopum apiculatum M. AND Liometopum occidentale var. luctuosum W. (HYMENOPTERA- FORMICIDAE.)

Rosa Martha Pérez\* Julieta Ramos-Elorduy\*\* Héctor Baragaño\* Laura Colin\* Consuelo Savin \*\*\*, \*ENEP-Iztacala, UNAM. Av. de los Ejidos. Los Reyes, Iztacala Tlanepantla, Edo. de México Código Postal 54090. \*\*Instituto de Biología UNAM CONACYT (Consejo Nacional de Ciencia y Tecnología) de México.

The ants of the Liometopum genus in México have an economical and nutritional value. The immature stages of the reproductive cast of both species presents in the Mexican Republic, Liometopum apiculatum M. and Liometopum occidentale var. luctuosum W. are known as "escamoles". They are eaten by many ethnic groups all over the country, even they were object of different religious cults by the ancient Aztecs and there are rituals that remain until our days.

We present the study of the alarm and pist pheromones of these ants. First we determined which was the gland involved in their secretion and we realized an ultrastructural study of the glands by means of electronic microscopy.

The chemical structure of the pheromones was determined by use of thin layer chromatography, I R and U V spectroscopy, gas chromatography and - mass spectrophotometry.

9

P9.-  
9 OPTICAL CONTROL OF UPWIND ORIENTATION TOWARDS A PHEROMONE SOURCE BY TETHERED FLYING GYPSY MOTHS.

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Max-Planck-Institut für Verhaltensphysiologie, D-8131 Seewiesen

A male moth orienting towards a chemically alluring female determines the upwind direction, his forward progress, flight direction and altitude from the ground pattern movement beneath him. By means of a new technique, a flight-simulator (see Poster: E. Kramer and R. Preiss), in tethered gypsy moths thrust, lift and flight-direction were measured simultaneously; with these signals the ground pattern was moved in a manner closely resembling free-flight conditions.

Experiments under optically simulated wind conditions are described in order to reveal the effective stimulus parameters and thus the mechanism underlying the optical flight control system.

Pg.-  
10

EFFECTS OF MYCORRHIZAL INFECTION OF HOST-PLANTS ON FEEDING AND DEVELOPMENT OF HELIOTHIS ZEA, SPODOPTERA FRUGIPERDA, AND SCHIZAPHIS GRAMINUM.

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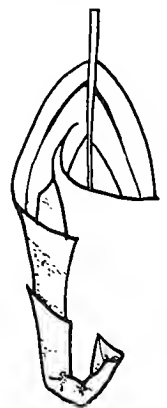
Plants of four soybean cultivars (resistant and susceptible to Heliothis zea) and one sorghum cultivar (susceptible to Schizaphis graminum) were infected with a mycorrhizal fungus to determine if infection altered host-resistance to certain herbivorous insects. Two-week old larvae of H. zea and S. frugiperda grown on detached leaves of mycorrhizal soybean plants weighed significantly less (30-60%) and time to pupation was delayed (1-6 days) relative to larvae fed leaves of control plants. Mycorrhizal infection of sorghum did not adversely affect the reproduction or feeding behavior (electronically monitored) of S. graminum; rather a trend toward better performance on mycorrhizal plants, compared to controls, was observed. These findings are discussed with reference to relative levels of sugars, amino acids, and total phenolics of infected vs. control soybean and sorghum plants.

Pg.-  
11

MEASUREMENT AND RECOGNITION OF LEAVES BY DEPOROUS SP.  
(ATTELABIDAE, COLEOPTERA)

KAZUHIKO SAKURAI (Dept. Zool., Kyoto University, Sakyo, Kyoto, 606 Japan)

The female weevil of D. sp. makes 'cradles' in which to lay eggs, by rolling the cut-out apical part of the leaf. The site of cutting is rather stable in leaves of a given size. Model leaves of various sizes and shapes were given to the female weevil, and it was investigated how the female decides the cutting site. The results suggested that the female does it on the basis of measuring the length of the main nerve from the leaf apex. The circumference and the area of the leaf are not measured in this species, but the area of the cut-out part appears to influence the number of eggs to be laid. Experiments showed also how the female recognizes the main nerve.



cradle of D.sp.

P9.-  
12

THE INTERFERENTIAL AND COMPETITIVE BEHAVIOUR OF  
TWO PREDATORS, Chrysoperla carnea (STEPHENS) AND  
Coccinella septempunctata L.

CETIN SENGONCA & BERND FRINGS

Institut für Pflanzenkrankheiten der Universität Bonn, W.Germany

Experiments were carried out to investigate the inter-ferential and competitive behaviour of Chrysoperla carnea and Coccinella septempunctata. The behaviour among different stages of one species and the occurrence of cannibalism were observed for each predator in the presence and absence of prey. Further the competition between both species was detected for several larval stages.

9

F9.-  
1

AGGRESSION AND GENETICS IN AN EUROPEAN TERMITE.  
OPEN AND CLOSED SOCIETIES OF RETICULITERMES LUCIFUGUS

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Ethological and biochemical (enzymatic polymorphism) analysis provide informations to elucidate if these societies are open or closed. In humid areas, societies are open in summer, population expansion is made by budding and reproduction is generally carried out by neoténics. In dry areas, societies are closed, a single pair of sexuals insures population expansion and formation of colony.

When they meet, workers exchange a chemical signature composed of contact pheromones on their cuticle using basic movements of recognition.

**F9.-**  
**2**

POLLINATION OF OPHRYS(ORCHIDACEAE) BY PSEUDOCOPULATING WASPS  
AND BEES

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Flowers of the orchid genus *Ophrys* mimic females for pollinating males of aculeate Hymenoptera by imitating important copulation-releasing signals. Each of the pollinating Hymenopteran species reacts to only one species of *Ophrys* by species specific copulatory behaviour patterns (Pseudocopulation). Landing on the flower the pollinator gets the pollinia glued to the head or to the tip of the abdomen, depending on the *Ophrys* species. The films demonstrate three cases of highly specific pollination behaviour on different mediterranean *Ophrys* species: (1) *Campsoscolia ciliata* (Scoliidae) on *Ophrys speculum*, (2) *Eucera barbiventris* (Apoidea, Anthophoridae) on *Ophrys scolopax*, (3) *Andrena flavipes* (Apoidea, Andrenidae) on *Ophrys fusca*. The last film is an example for abdomen pollination. All films with high speed sequences. In co-operation with : Institut für den Wissenschaftlichen Film, Göttingen.

Section 10 Social Insects .....  
R 10.1. Wasps .....  
R 10.2. Bees .....  
R 10.3. Parasitism of Honeybees by Varroa jacobsoni .....  
R 10.4. Termites .....  
S 10.1. Myrmecology .....  
S 10.2. Taxonomy and Morphometry of Honeybees (Apis) .....  
S 10.3. First Steps in Socioevolution of Bees .....  
S 10.4. Queen Loss and Queen Maintenance in Social Hymenoptera  
During Evolution .....  
S 10.5. Bee Behaviour .....  
P 10. ....  
F 10. ....



**R10.1.**  
**1** ATTACHMENT TO THE NEST AND WORKER-LIKE ACTIVITIES IN YOUNG  
QUEENS: EFFECTS ON REPRODUCTION IN DOLICHOVESPULA MEDIA  
(RETZIUS 1783) - (HYM., VESPIDAE)

HAESELER, V.

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Few details, partly contradictory, are known about the attachment to the nest of young queens in social wasps. - Young ♀♀ of *Dolichovespula media* may not only return to their nest over a longer period of time but also forage and do sanitation duties under exceptional conditions. Thus they are able to perform, apart from nest building activities, essential worker activities and by provisioning the numerously emerging ♀♀, even towards the latter stages of the seasonal cycle, they guarantee a higher reproduction rate.

**R10.1.**  
**2** THE WESTERN YELLOWJACKET IN HAWAII AND ITS CONTROL

VINCENT C.S. CHANG

Hawaiian Sugar Planters' Association, P. O. Box 1057, Aiea, Hawaii 96701

The Western yellowjacket (*Vespula pensylvanica* (Saussure)) has become an important pest on the Island of Hawaii, State of Hawaii, USA, since it was first reported in 1978. The wasp was found mainly in forest and in agricultural areas above 1000 ft elevation and often built huge perennial underground nests. Many of the nests examined had a diameter of over 1.2 m and had more than 40 tiers of combs. The nests often contained more than 50,000 cells. Queens, males, and workers were found flying year round. Peak population was between July and November, depending on the weather in the area. Adequate control can be achieved by dusting the nest with 1% "Ficam" dust in the non-agricultural areas and by using a baiting system consisting of 0.5% "Knox-Out" in tuna cat food, a wasp attractant (n-heptyl butyrate), and an effective bait dispenser, in agricultural areas.

**R10.2.** PRELIMINARY INVESTIGATION ON THE DISTRIBUTION OF AFRICANIZED HONEY  
**1** BEES IN ARGENTINA

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Department of Entomology, University of Georgia, Athens, GA 30602 U.S.A.

While the northward movement of Africanized bees, since their introduction into Brazil in 1956, has now reached Costa Rica, the southern distribution of these bees into Argentina is not clear. A study on the distribution of these bees was initiated in Argentina in 1983. The defensive behavior of roughly 600 colonies in 9 provinces was determined. In addition, 570 samples of honey bees were collected from the brood nest area of colonies for morphometric analysis. The testing for defensive behavior and the collection of honey bee samples covered areas north and south of the presumed distribution limit of Africanized bees in Argentina. The findings will be discussed.

**R10.2.** A CONSERVATION STRATEGY IN COLONIAL THERMAL RESPONSE  
**2** TO COLD STRESS IN HONEY BEES

E.E. SOUTHWICK

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Honey bees, Apis mellifera carnica Pollmann, control the internal nest environment under a broad range of environmental conditions. Under cold stress, individuals in a colony act in concert so as to maintain a high core temperature. This temperature maintenance is successful only at considerable cost to the colony. In this paper I present data on respiratory metabolism ( $\dot{V}O_2$ ) and conductance (C) through the "mantle" that shows cooperative control. In small colonies of 2000 workers and a queen subjected to 2°C overnight, minimum  $\dot{V}O_2$  attained was 10.63 watts/kg, and minimum conductance was 0.49 watts kg<sup>-1</sup>°C<sup>-1</sup>. These minima were not maintained throughout the night but showed rhythmic patterns of 1.3 hr duration, although core temperature was maintained. Possible effectiveness of this pattern in conservative thermal control is discussed.

**R10.2.** THE FORAGING BEHAVIOR OF HONEY BEES (APIS MELLIFERA L.) ON BRASSICA  
**3** CAMPESTRIS (VAR. CANDLE, TOBIN) AND B. NAPUS (VAR. ANDOR, ALTEX,  
REGENT)

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Honey bee (Apis mellifera L.) foraging behavior was observed on five varieties of canola. Two cultivars of Brassica campestris (var. Candle, Tobin) and three cultivars of B. napus (var. Andor, Altex, Regent) were examined. Observations were made at 2-hour intervals from 8:00 a.m. to 8:00 p.m. over a 2-3 day period. Foraging behavior was correlated with nectar secretion, pollen collection, temperature and humidity. Honey bees were also observed to determine if any varietal preferences existed. Further comparisons were made between individually bagged and unbagged plants to determine the effect of honey bee pollination on seed yield.

**R10.2.** AN ETHNOENTOMOLOGICAL SURVEY OF AMAZONIAN INDIANS  
**4**

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Indigenous peoples of Amazônia have adapted for millenia to insects as important factors in their ecological systems. This paper surveys the role of insects as food, crop pests, medicinals, influences in house types and seasonal human movement, and importance in myth and folklore. Special emphasis is given to indians as folk ethologists, particularly in the study of stingless bees (Meliponinae). Social insects are discussed as "Natural Models" for the Kayapó Indians, who symbolically recognize ñy/nhy (wasps, bees, ants, and termites) in both myth and ceremony. Concluding comments suggest that ethnoentomology can not only offer social insights into indigenous cultures, but can also provide science with new data and testable hypotheses.

R10.3.  
1

# NEUROSECRETION AND THE START OF OVIPOSITION IN THE MESOSTIGMATIC MITE VARROA JACOBSONI

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Histological and endocrinological investigations on the bee-parasitic mite Varroa jacobsoni should elucidate the complicated system of reproduction in this parasite. Varroa mites infest adult bees and feed on the haemolymph but they only produce offspring on larvae and pupae inside the cells. Mite brains stained in toto with victoria blue indicate, that the storage of neurosecretory products in the releasing centers of the cortex takes place in the time of adult bee infestation or when mites enter cells without producing eggs on the bee larvae. Varroa females do not show this storage, when pregnant. Obviously the release of this material starts the incorporation of vitellogenin into the largest egg.  $JH_{III}$  is involved in this process as well.

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R10.3.  
2

# THE USE OF DRONE BROOD IN THE CONTROL OF VARROA DISEASE OF BEES

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The use of drone brood to control the mites Varroa jacobsoni Ouds (Acarina: Varroidae) has been studied under the condition of our country.

This study has started in the winter of 1981-82, and ten beehives were used for this work, which had a very small infestation of mites of V. jacobsoni.

In December of 1982, that is a year later, without any treatment, these beehives had a small rate of infestation in the bees, 0,38%-2,72%, and only a beehive had a relative big infestation about 8,23%. In the spring of 1983, the natural drone brood took away of the hives and destroyed. In the same time, during the months April and May, in these hives two-four drone combs (trap combs) were used which removal when the drone broode was capped.

In a check on these bee-hives in August 31, 1983, the infestation in eight of them appeared a reduction in relation to the first infestation, about 43-100%. Only, in two hives an increase of 47,36% and 132,26% respectively, appeared.

Nevertheless in these two hives the rate of parasitism was in low level, i.e. 0,56% and 2,81% respectively, which is far to a dangerous level. In the contrary, to the ten control beehives, with the same infestation in the spring of 1982, the mite infestation, in the August of 1983 reached in dangerous level.

So, it seems from this research that the control of Varroa disease, may be give good results, by the use of drone brood, at least in beehives with low infestation.

**R10.3.** NUTRITION AND REPRODUCTION IN THE ECTOPARASITIC  
**3** HONEY BEE (APIS SP.) MITE, VARROA JACOBSONI.

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Varroa jacobsoni is an established ectoparasitic, stenophagous mite of eastern honey bee, Apis cerana. Recently it has been transmitted to the western honey bee, A. mellifera. All the developing stages of the mite suck hemolymph from all honey bee stages except the sealed ones. Due to this the entire colony succumbs after 3-4 years. Success to control Varroa mite effectively could not be achieved due to lack of knowledge about its host-parasite relationship and reproductive biology. In the present study, immunological, immunocytochemical and histological studies show that there is a undigested resorption of Apis hemolymph proteins into the hemolymph of the mite and their incorporation into the vitellogenic oocytes of Varroa. This indicates a selection pressure for rapid oogenesis in the mite to synchronize with the short time available for reproduction inside the capped honey bee brood cells.

**R10.3.** A STUDY OF THE PREFERENCE OF VARROA JACOBSONI FOR DRONE LARVAE OF  
**4** APIS MELLIFERA REARED IN WORKER VS. DRONE CELLS.

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It has been previously demonstrated that the mite Varroa jacobsoni prefers drone brood over worker brood for reproduction. The present experiment investigates the influence of the location of drone larvae. Empty combs containing worker and drone size cells were placed at the same time in laying worker colonies. The data indicate that drones reared in drone cells are preferred over those reared in worker cells.

**R10.3.** STUDY OF PRODUCTION OF FOOD AND BROOD IN HIVES OF *Apis mellifera* INFESTED WITH THE MITE *Varroa jacobsoni*.

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*Apis mellifera* hives were at each 2 monthes, analysed for brood (egg - larvae, pupae) and food (honey, pollen) area and it was also estimated the population of the mite *Varroa jacobsoni* by the method of GONÇALVES et alli (1981). The results were: a positive correlation ( $p < 0,05$ ) between egg-larvae brood and pupae brood ( $r=0,659$ ), pollen ( $r=0,559$ ), honey ( $r=0,225$ ). However, the egg-larvae amount is negatively correlated with the percentage of adults infested ( $r=-0,276$ ); 2. Positive correlation ( $p < 0,05$ ) between pupae and honey areas ( $r=0,228$ ) and pupae and pollen areas ( $r=0,439$ ). 3. Positive correlation ( $p < 0,05$ ) between honey and pollen areas ( $r=0,224$ ); 4. Positive correlation ( $p < 0,05$ ) between percentage of infested brood and adults ( $r=0,318$ ); 5. No correlation between temperature, egg-larvae and pupae areas. 6. Positive correlation ( $p < 0,05$ ) between temperature and percentage of infested broods and adults by the following equations:  $Y = - 2,2982 + 0,5044X$  and  $Y = 4,0808 + 0,6908X$  ( $X$  is equivalent the temperature). CNPq - PIG IV.

**R10.4.** THE UTILIZATION OF ENERGY RESERVES BY FOUNDING PAIRS OF THE HARVESTER TERMITE HODOTERMES MOSSAMBICUS (HAGEN)

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Immediately after swarming *Hodotermes mossambicus* reproductives construct a nuptial cell approximately 20cm below the soil surface where colony founding occurs. The first larvae appear approximately 28 days later and the first workers after a further 45 days. Since only the workers harvest, the young colony is initially dependant on the reserves of the reproductives for growth and survival.

At swarming dry material constituted between 45 and 50% of the alates. The bulk of this consisted of neutral lipids particularly triglycerides. Small quantities of glycogen were present. When the first larvae appeared there had been a substantial drop in neutral lipid content, a large increase in glycogen content and an overall slight decrease in dry mass. At worker appearance both the glycogen and lipid content had dropped dramatically accounting for more than 80% of the 50% decrease in dry mass. The glycerol released during metabolism of triglycerides could have contributed to glyconeogenesis but glyconeogenesis by gut flora from fatty acid precursors is a distinct possibility. This was reinforced by the observation that young larvae feed on a viscous droplet on the tip of the reproductive's abdomen. The droplet contained large quantities of glycogen and traces of amino-acids.

**R10.4.**  
**2** ON SWARMING SEASON AND EMERGENCE TIME OF THE DRYWOOD TERMITE  
BIFIDITERMES BEESONI (GARDNER) WITH ENVIRONMENTAL INFLUENCES

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The swarming pattern of the drywood termite Bifiditermes beesoni (Gardner) was observed during 1976-77 at Lahore, Pakistan in the infested area of an orchard under natural conditions and compared with the colonies of the same origin but were placed about 200 metres apart in an area surrounded by buildings. In the natural colonies, the swarming started 21 June in 1976 and 19 June in 1977 and ended on 17 August in 1976 and 13 August in 1977. On the other hand, in the civilian area it started a bit earlier (20 June in 1976 and 16 June in 1977) and continued late in the season (26 August in 1976 and 3 September in 1977). Of the total flights recorded in the civilian area ( $n = 110$ ), 37.2 per cent initiated 1 - 29 minutes before sunset. As against this, in nature the swarming initiated always after the sun-set. The flights which started earlier lasted longer and produced more alates. In nature, the peak emergence was recorded between 2000 and 2030 - 2100 hours, whereas the colonies of the civilian area produced maximum alates during 1900 and 2000 hours.

**R10.4.**  
**3** RELATIONSHIP BETWEEN NUMBER OF SWARMING ALATES AND COLONY  
SIZE OF THE DRYWOOD TERMITE BIFIDITERMES BEESONI (GARDNER)

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Four whole colonies established in trees of Prunus domestica were dug out and fixed in special ant-proof cemented troughs. A sac was held over each colony and connected to the light-trap designated for these studies, where every swarming alate was collected and counted. At the end of the swarming season, the colonies were carefully opened up and their populations were also counted. It was found that during a swarming season, the mature colonies produce a specific proportion of their members as swarming alates (swarming alates and mother colony population ratio = 1: 2.30 to 2.32). They constituted 30.22% to 31.55% of their total populations. These studies may be helpful for estimating the population of colonies upon counting their swarming alates.

## 510.1. BIOSYSTEMATICS OF THE SOCIAL PARASITIC ANT

### 1 GENUS EPIMYRMA (HYM., FORMICIDAE)

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The genus *Epimyрма* comprises two species (*E.ravouxi*, *E.stumperi*) exhibiting the ordinary biology of slavemaking ants. A second group of species represents an evolution towards a derived kind of parasitism, combined with a curious inbreeding system. *E.bernardi* has retained a functional worker caste and is still conducting slave raids, however, the young queens mate within their mother nests, which they leave on foot for colony foundation after the hibernation. *E.kraussei* (= *E.vandeli*, = *E.foreli*) has reduced the worker number and the slave raiding behavior. *E.corsica* is definitely workerless. Both species, like *E.bernardi*, exercise a permanent inbreeding. The queens of all these *Epimyрма* species found their colonies by throttling the host colony queens to death, all have identical karyotypes of  $n=10$  chromosomes, thus doubtlessly forming a monophyletic genus.

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## 510.1. ANT NESTS IN TIDAL MEADOWS IN DENMARK

### 2

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In tidal meadows the conspicuous plant-covered nests made by *Lasius flavus* F. often occur in high densities. The domes are made of sand and they last for many generations. The nests can also be inhabited by other ant species e.g. *Lasius niger* L., *Myrmica scabrinodis* Nyl., and *Myrmica rubra* L. The size of the nest dome and the population density of *Lasius flavus* are correlated by a lineary equation. The distribution of nests in the tidal meadows is strongly dependent on the drainage of the area. In homogeneous areas the distribution is between random and uniform. There is a high correlation between mound size and territory, which confirms the supposition that territory is the limiting factor for nest size in this area where more than 15% of the land is covered by ant nests.



**S10.1.** THE ANT FAUNA OF COASTAL AND CONTINENTAL ISLANDS IN  
**3** THE NETHERLANDS

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Sandy islands near the coast of The Netherlands and W. Germany were investigated on ants. According to expectation, the number of ant species is strongly correlated with the size of the areas, mainly as a consequence of increasing habitat diversity with size. Although the distances between the islands are small, it became most likely that the isolated position of the islands is also a determining factor for the number of ant species which are found there.

The number of species increases much more strongly with the areas of the coastal islands than of 'ecological islands' on the continent, e.g. chalk grasslands that are situated amid uninhabitable farming land. This is not only explained by the more isolated position of the coastal islands, but also by their more dynamic character. Especially the small coastal islands are very instable and this leads to a relative poor ant community.

Species, which appear first to (re)colonize an area have a wide habitat (niche) breadth and probably a good reproduction and dispersion capacity too; they are true pioneers. On small islands only a limited number of pioneer species were found and it is likely that a pioneer species which arrived first impedes the settling of others. The number of ant species will increase as soon as stable and diverse habitats develop.

**S10.1.** INVESTIGATIONS ON THE ANT FAUNA (HYM., FORMICIDAE) OF  
**4** CALLUNA HEATHLANDS IN NORTHWESTERN GERMANY

ASSING V.

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Since 1980 the ant fauna of several Calluna heathlands north of Hannover and of parts of the "Lüneburger Heide" has been investigated by means of hand sampling, pitfall trapping, random square sampling, square meter sieving, and Kempson extractions.

Altogether, 29 ant species were recorded. The ant communities of the sample areas are compared with regard to distribution, preferred microhabitats and nest densities.

The significance of the different methods employed in this study is discussed with respect to the phenology of the two female castes of some species and to applicability for sampling ants in general.

**S10.1.** HABITAT AND NICHE ANALYSIS OF GRASSLAND ANTS  
**5**

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Results of the analysis of ants in 41 grassland habitats and four within habitat niche dimensions support Hanski's core and satellite species hypothesis. Niche breadth and habitat distributional breadth are positively correlated in core and negatively in satellite species. Also positive correlation was measured between density and ecotope /niche+habitat/ breadth values of ants.

From the niche dimensions studied /food size, parasitism, vertical microhabitat and daily rhythms of activity/ most intensive post-competitive segregation was established in activity and vertical microhabitat dimensions.

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**S10.1.** THE OUTDOOR PERSISTENCE OF MONOMORIUM PHARAONIS (L.)  
**6** (HYMENOPTERA, FORMICIDAE) COLONIES THROUGHOUT THE YEAR

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In the years 1981-83 parasite fauna of small mammals in a refuse dump near České Budějovice (South Bohemia) was studied. Detailed examination of the dump about 1 km distant from the nearest dwelling was initiated after several *Monomorium pharaonis* workers had been detected in hair of a sewer-rat on May 26, 1983. Intensive reproduction of *M. pharaonis* ants in the dump in the warm seasons of the year was demonstrated. Ant colonies formed close under or directly on the surface of the dump. Living ant workers were found on the dump surface even late in autumn when morning ground frosts (up to  $-5^{\circ}\text{C}$ ) had been recorded for several days. Captures into traps with egg yold bites demonstrated the survival of ants 5-10 cm under the dump surface throughout the entire winter period.

## S10.1. 7

### EFFECT OF AN ALIEN ANT ON A NATURAL ECOSYSTEM

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In Capensis, the world's smallest plant Kingdom, many plants rely on native ants for dispersal and survival. Special structures on the seeds attract ants which then carry them to their nests where they are protected from rodents. Where the alien Argentine ant (Iridomyrmex humilis Mayr) is present many local species are displaced. Since the Argentine ant does not carry seeds to their nests they are left exposed. An area with low ant diversity also had low plant species diversity.

## S10.1. 8

### TEMPERATURE REGULATION IN WOOD ANTS (*FORMICA POLYCTENA* FÖRSTER)

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Wood ants of the *Formica rufa*-group (Hymenoptera, Formicidae) maintain in their nest hills a temperature of 25-30 degrees C. Experiments demonstrate, that the nest temperature is regulated by the ants. Different mechanisms for this regulation are discussed.

**S10.1.** WATER BALANCE OF THE RED WOOD ANT, FORMICA POLYCTENA  
**9**

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The water exchange rates of adult workers, pupae and larvae of the red wood ant, *Formica polyctena*, were measured gravimetrically and by means of tritium-labelled water. Between 14 to 35° C and below about 90% r.h. the transpiration rates were nearly proportional to saturation deficit, in adult workers however only as long as they were not active. Sorption rates were proportional to r.h., but significantly lower than transpiration rates, even above 97% r.h.. Larvae showed about 1/3 and pupae about 1/10 of the transpiration rates for adult workers.

**S10.1.** THE ACCUMULATION AND UTILIZATION OF FOOD RESERVES BY THE  
**10** WORKERS OF TETRAMORIUM CAESPITUM (L.) (HYMENOPTERA, FORMICIDAE)

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Goldsmiths' College

On eclosion, the workers of Tetramorium caespitum (L.) rapidly accumulate food reserves, principally in the form of fat, so that it constitutes up to 75% of all other body components. These well endowed workers, equivalent presumably to the "Speichertiere" of Formica spp., are associated with the sexual brood in the spring. They lose much of their reserves as the brood grows. The proportion lost relates to the number of gynes being reared and it remains uncertain whether the losses are sufficiently drastic to result in death. However, there is some evidence that they may be able to rebuild the reserves for a second season of brood rearing.

**S10.1.** PRODUCTION ECOLOGY, ENERGETICS AND GENETIC STRUCTURE OF POPULATIONS OF  
**11** *LASIUS NIGER*: AN INTEGRATED STUDY

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Sex-ratio strategies were studied in three coastal dune populations of the monogynous ant *Lasius niger* L. The populations differed in age and availability of resources. The proportional dry weight investment in queens was determined per colony and on the population level. Energy investments during the different developmental stages of queens and males were estimated from laboratory measurements on caloric content and respiration. Energy investment ratios (queens/males) were lower than the corresponding dry weight ratios. Observed sexual investments appeared to be in good agreement with expectations based on (presupposed) full worker control and between-caste relatedness. The latter was estimated after allozyme variation analysis at a marker locus. Indications were that, in food limited habitats males are also produced by workers. This effect, together with an increased frequency of multiple inseminated queens (due to a larger excess of males) may shift the genetically optimal investment ratio in queens from 3 back to 1.

**S10.1.** SOCIAL REGULATION OF QUEEN FERTILITY IN THE FIRE ANT,  
**12** SOLENOPSIS INVICTA

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The egg laying rate of fire ant queens in broodless nests of workers is very low, but increases logarithmically in relation to number of larvae. Only the oldest larvae, probably just prior to pupation, are capable of stimulating egg-laying. Young larvae, when present with old larvae, inhibit the egg-laying effect of old larvae. The effect of the larvae requires 4 days to reach its maximum. Neither the age nor body size of the workers affects their ability to transmit the stimulating effect of larvae to the queen. There is evidence that a bulk material flows from the old larvae to the workers to the queen and into the eggs, but its nature is presently unknown.

S10.1.  
14

#### DUFOUR GLAND MORPHOLOGY IN ANTS (HYMENOPTERA, FORMICIDAE)

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The Dufour gland in ants essentially is a sac-like reservoir which is lined by a monolayered glandular epithelium. The gland cells are characterized by a well developed smooth endoplasmic reticulum and numerous but rather small mitochondria.

Considerable differences, however, can be observed in the cellular organization in the different ant subfamilies, as was revealed by comparative studies of over 50 species belonging to 7 subfamilies. In this way, a rather simple epithelium without special modifications was found in most of the Myrmicinae and Ponerinae. In the Formicinae, on the other hand, a characteristic subcuticular position of the mitochondria is observed as well as a very thick basement membrane, whereas Dolichoderinae and Myrmeciinae each show a different kind of apical microvillar processes. In the African Dorylinae, the epithelium has a crenelated appearance with deep basal invaginations, while the New World Ecitoninae lack any crenelation but exhibit a basal layer of membraneous foldings.

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S10.1.  
15

#### COMPARING FORAGING RHYTHMS IN FORMICA ANTS

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Light-dark induced diel activity rhythms of forager ants were compared for different species of *Formica* s. str. (laboratory colonies, automatic recording of traffic to a foraging field). A 12:12 LD regime induced cyclic activity pattern of the same general shape in each species tested but peak activity occurred at different points relative to the noon of the artificial day: in one species the activity of ants leaving the nest culminated shortly before or after the onset of light ("early morning") while it in another coincided with the noon. The diel preiodicity of foragers was more marked than among extranidal non-foragers and starvation was found to increase the amplitude of the rhythm. The nature of the rhythm (true circadian or not) as well as its ecological significance is discussed.

**S10.1.** THE SENSITIZATION OF YOUNG WORKERS TO QUEENS IN THE ANT  
**16** MYRMICA RUBRA L.

E J M EVESHAM

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The effect on workers born into a queen-containing society upon their subsequent brood-rearing behaviour was tested in the polygynous ant Myrmica rubra L., using small summer and large, overwintered larvae. Workers reared from "birth" in the presence of queens, did better at controlling larval growth compared to workers reared without queens. The current presence of queens had little influence. A critical period exists when young workers become sensitized and perhaps imprinted to the presence of queens. The character of the workers, size of the colony and queen/worker ratio influence the degree of worker response towards queens.

**S10.1.** INTERSPECIFIC CHRYSOMELID-ANT  
**17** INTERACTIONS IN MAYA-BASED AGROHYDRAULIC SYSTEM

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Members of the Family Chrysomelidae, Cerotoma ruficornis, Diabrotica balteata, D. flaviventris, Systema s-literata, Acalymma cornutum, A. blomorum are major defoliators of beans (Phaseolus spp, Vigna sp.), cucurbits, solanaceous vegetable crops and corn in the rediscovered agrohydraulic system with pre-Hispanic Maya roots. Solenopsis geminata, Monomorium and Tapinoma species, ubiquitous to the bean, vegetable and cereal crop fields, displayed various interspecific interference interactions with the chrysomelids and reduced their herbivory to a great extent, as was shown by the ant-exclusion experiments. The extrafloral and stipler nectaries on the plants seem to direct the fidelity of ants to their paths such that ant-herbivore interference is possible during the foraging by ants. The plants also seem to exclude ants from pollinating them through various morphological adaptations, while using them as a defense against the herbivores. The chrysomelids may flee, show akinesis or reflex-bleed to escape the aggression by ants during their feeding on the plant foliage. The interference by ants and their alarm-attack behavior against the herbivores may have greatly affected the distribution of plant nectaries on the shoots most vulnerable to herbivory.

**S10.1.**  
**18** SOCIAL DOMINANCE HIERARCHY AS THE BASIS OF ANT COMMUNITY  
STRUCTURE

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Ecological niches of many ant species overlap, leading to a high competition level. The ability of an ant colony to occupy an ecological niche depends on its position in the social dominance hierarchy. Hitherto three essential levels have been distinguished. The lowest level (I) consists of nest defending species (e.g. *Leptothorax* s. str.). Their colonies can occur close to each other and they can share a common food source. The middle level (II) is formed by the nest and food source defenders, like *Tetramorium caespitum* L. They tolerate other colonies on their trophic field, but at some distance from their own, and they do not admit their workers to their food sources. Species defending their whole trophic field (e.g. *Formica* s. str.) from the highest level (III). They do not tolerate any other territorial colonies on their trophic field, although subordinate level I species can live there. Such colonies occupy the richest niches and dislodge other species, lower in hierarchy, into less favourable conditions.

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**S10.2.**  
**1**

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Taxonomy and morphometrics of honeybees: An overview

Species recognition in the genus *Apis* is feasible by a number of conspicuous qualitative characters, while the intraspecific discrimination of different geographic taxa is based on quantitative differences. Two species - *A. mellifera* and *A. cerana* - distributed over very large areas, show clear though sometimes only small geographic variations, which can be analyzed by morphometric-statistical methods only. During sampling one has to consider carefully the possibility of hybridization by lack of geographic barriers and by transport of colonies. Correctly selected characters reveal the existence of a considerable number of distinct geographic types (races) using multivariate analysis.



**S10.2.** THE EFFECT OF NURSE BEE PHENOTYPE AND COMB SIZE ON BEE  
**3** RACE IDENTIFICATION

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The progeny of European and Africanized honey bee (Apis mellifera) were raised with all possible combinations of European and Africanized nurse bees and comb types. Samples of these progeny were weighed and analyzed morphometrically. Where possible, these combinations were tested also on the progeny of F<sub>1</sub> matings.

**S10.2.** METHODS OF MULTIVARIATE ANALYSIS IN HONEYBEE BIOMETRICS  
**4**

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HONEYBEE BIOMETRICS GENERALLY IS PERFORMED FOR ONE OR MORE OF THE FOLLOWING PURPOSES:

- Assessing population structure
- Discriminating between populations
- Classifying populations
- Sorting an unknown sample among already known populations

This paper reviews the different methods of multivariate analysis which have been devised to meet these goals. The choice between alternate methods is discussed as a function of the data structure.

S10.2.  
5

An automated procedure for identification of honeybees

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The wings, hind leg, and third abdominal sternum of a worker bee are mounted on a microscope slide. Images of the parts are projected optically onto an electronic digitizer tablet. Point coordinates for 24 measurements are transmitted to a computer from the digitizer. A program prompts the operator for the measurements to be taken, calculates the distances and angles required, and then computes the probabilities that the bee was Africanized or European in origin. The method significantly reduces the time to make measurements and reduces errors in measurements. The use of measurements in the morphometric analysis of honeybees in the Western Hemisphere will be discussed.

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S10.2.  
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MORPHOMETRICS OF THE CARNIOLAN BEE (APIS MELLIFERA CARNICA POLL.) AND SIMILARITIES WITH GEOGRAPHICALLY ADJACENT RACES.

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Samples from the distribution area of Apis mellifera carnica are compared with regard to their similarities within and between colonies. Each of 145 samples consisted of 20 worker bees from one colony. The total variance of the race is demonstrated by the 10 best discriminating characters. Several subtypes or ecotypes can be distinguished by cluster analysis. The comparison with the geographically adjacent races shows transition areas with the Italian honeybee, Apis mellifera ligustica Spin., but clear separation from the dark bee Apis mellifera mellifera.

**S10.2.** MORPHOMETRIC ANALYSIS OF BEE POPULATIONS IN ITALY;  
**7** NORTHERN PART AND TYRHENIAN COAST

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Approximately 100 samples, each consisting of 20 worker bees, were collected in Northern Italy and along the Tyrrhenian coast. Using morphological measurements followed by univariate and multivariate statistical analysis, the variability of A.m.ligustica race was studied within a number of preselected areas and some transition areas with A.m.mellifera towards France, A.m.carnica towards Austria and A.m.sicula were identified. This research has made us able to choose the characters that are most suitable for distinguishing the A.m.ligustica race from the other neighbouring races and at the same time most suitable for studying intraracial variability (ecotypes).

**S10.2.** RACES OF THE INDIAN HONEYBEE IN THE HIMALAYAS  
**8**

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Geographic variability of the Indian honeybee (Apis cerana indica F.) was studied morphometrically by collecting 60 samples of worker bees from each of the 27 localities of north-west ( $29^{\circ}$  to  $36^{\circ}$  N,  $74^{\circ}$  to  $81^{\circ}$  E and 587 to 3017 metres altitude) comprising of Himachal and Kashmir regions and north-east ( $20^{\circ}$  to  $27^{\circ}$  N,  $92^{\circ}$  to  $95^{\circ}$  E and 790 to 2011 metres altitude) Himalayas comprising of Manipur, Mizoram and Nagaland. Bees of north-west Himalayas were named as Kashmiri and Himachali bees and those of north-east as Manipuri bees.

Statistical analysis of the data obtained for 55 characters revealed a significant positive correlation with altitude for 20 characters in Kashmiri, 38 in Himachali and 23 in Manipuri bees. Bees from mountainous zone were significantly bigger in size and darker in color than those of submountainous zone. Morphometric comparison of bee populations of Himalayas revealed significant differences in size (Kashmiri bees > Himachali bees > Manipuri bees) for most of the characters studied and Manipuri bees were darker in color than Himachali and Kashmiri bees. These results suggest that bees of these regions are three distinct races and such phenotypical variability is being utilized for the selective breeding.

### **S10.3.** **1** PATTERNS OF SOCIAL EVOLUTION IN THE HALICTIDAE (SWEAT BEES)

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Eusocial behavior has evolved independently in Augochlora, Augochlorella, Halictus, Evylaeus, and Dialictus, and multiple times in the latter two genera. An analysis of social structure of Western Hemisphere sweat bees along a latitudinal gradient indicates that well-defined castes and mother-daughter associations are typically adaptations for brief foraging seasons and characteristic of north temperate species. Tropical social species usually have poorly separated worker and reproductive castes and single-generation colonies. A worker caste has repeatedly evolved within the Halictidae whenever related bees co-inhabit the same nest and environmental factors strongly select against a solitary bee initiating her own nest.

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### **S10.3.** **2** SOCIALITY AND INTRASPECIFIC COMPETITION IN CARPENTER BEES (XYLOCOPA)

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Many *Xylocopa*-species nest in aggregations and re-use the excavated tunnels of previous generations for their brood rearing. This often implies the sharing of parts of the nest by several females. Also, mothers may share a nest with their emerged offspring.

Generally, differences in activity patterns between adult females sharing a common nest occur, resulting in division of labour, one female monopolizing reproduction. In distinction to higher forms of sociality this dominant female is the major forager. Nestmates receive food from her, in return they guard the nest entrance.

The interactions between adults within a nest will be described. The relatedness with nestmates seems to play a minor role at the most in determining an individuals' reproductive success. Phenotypic characters seem to be of paramount importance. Reproductive competition might be instrumental in the regulation of population size.

S10.3.  
3

### MATING BEHAVIOR AND SEX ATTRACTION OF EUCERA PALESTINAE

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Eucera palestinae is a ground nesting solitary bee that lives in dense aggregations. The bees overwinter as adults in their nests and emerge in early spring. The males emerge up to a week before the females, and fly back and forth in the nesting area waiting for a female to emerge. Upon emergence, the female is spotted by males and several of them approach in an attempt to mate with it. The approaching males are extremely aggressive towards each other trying to overcome all other males and be the one to copulate with the female. Upon copulation the female becomes unreceptive and rejects any mounting attempts by the males. Experiments have demonstrated that the initial attraction of males towards the female is visual and is triggered by the much slower flight of the female. A virgin female, however, is also distinguished by its scent. In order to investigate this component in the premating behavior, bioassays using tethered males which were scented with various female odors were carried out. The reaction of the cruising males in the nesting area toward a control (pentane treated) male was a short inspection. This was also the reaction towards a tethered male scented with any of the following female odors; head extracts, Dufour's gland secretion, intersegmental gland secretion and abdominal sternite extracts. In contrast, when the tethered male was scented with either whole abdominal extracts or tergite extracts, mounting and copulation attempts upon the tethered male were commonly observed. The source of this sex pheromone are small dermal glands that are attached to the abdominal tergite.

S10.3.  
4

### TERRITORIAL BEHAVIOUR OF THE KLEPTOPARASITE REDUCES PARASITIC PRESSURE IN COMMUNALLY NESTING BEES.

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Females of the kleptoparasitic bee genus Nomada lay their eggs in nests of Andrena and other bees. Nomada females fight to obtain monopoly of Andrena nests. As a result a territorial system is built up. Regardless of its size an Andrena nest will be infested by only one or very few Nomada females. By nesting communally Andrena bees are able to reduce the per capita incidence of parasitization. Therefore, communal nesting may be interpreted as a strategy evolved to reduce the effects of territorial parasites.

### 510.3. ON THE SOCIAL STRUCTURE OF EUGLOSSA CORDATA NESTS

5

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Euglossa cordata is one of the commonest euglossine bee found at Ribeirão Preto, SP. The biology of this species is being studied since 1980 under laboratory conditions. The nest is founded by a single female that lays 6-10 eggs. After the completion of the last cell she spends most of her time at nest entrance. When daughter female emerge some leave and construct new nests elsewhere; others stay and an association of adults starts. This association may include adults of either two successive generations (mother x daughter) or of the same generation (sister x sister) if the mother is dead. Thus, when two or more females are present in the nest distinctive dominant and subordinate behaviour can be seen. Each subordinate female (daughter or sister) constructs, provisions and oviposits in her own cells. The dominant female is commonly the oldest bee (mother or sister). She not only rarely leaves the nest but becomes the major guard bee and oviposits in cells provisioned and laid by the subordinate females. The oviposition of the dominant female is always preceded by oophagy. After the death of the dominant female the oldest subordinate replaces her. These findings show that this kind of social organization is supported by dominance and oophagy and that all the subordinate females present enlarged ovaries and oviposition capacity.

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### 510.3. Geographic Variation in the Social Organisation of Halictus ligatus

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LAURENCE PACKER

Halictus ligatus is an extremely widespread halictine bee which shows considerable variation in its social organisation. In southern Florida this species has continuous overlapping generations with the nest population building up to about twenty workers co-existing with the queen. Just north of Toronto the colony cycle is annual with one worker brood of up to fifteen bees. Further north, near the edge of its range, the colonies are tiny - with one brood of about four workers. Morphological caste differentiation seems to increase from north to south but the workers in the Florida population are more likely to mate and lay eggs than those further north. Findings from these recent field studies will be compared with data published on New York and Trinidad populations. It will be shown that there is considerable geographic variation even within a narrow range of latitude. Speculations concerning the origin and further elaboration of social behaviour in Halictus will be made on the basis of taxonomic, biogeographic and social data.

**S10.3.**  
**7**

The Function of Genealogical Relationship in Heirarchy Formation in the Primitively Eusocial Bee Lasioglossum zephyrum

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Both males and females of the primitively eusocial bee Lasioglossum zephyrum (Hymenoptera: Halictidae) have the ability to distinguish between female kin, which has been shown to be important in both mate and nestmate identification. However, little has been reported regarding how kin recognition mediates nestmate interactions during dominance hierarchy establishment. To investigate this problem artificial nests of 6 female bees were established in which the genealogical relationships among them ranged from full inbred sisters to no relationship by descent. Interactions with the newly established queen as the focal individual were then recorded. Data were also recorded on the state on nest development, division of labor, worker age and ovarian development. The report will focus on how interactions between the queen and worker correlate with the genealogical relationship between the two and how they correlate with these other factors. To date, in 7 of 11 nests composed of unrelated females one female died in the process of hierarchy formation. This has never been observed in nests composed of full sisters. Furthermore, interactions tend to be more aggressive in nests composed of unrelated females, particularly between the queen and certain workers.

**S10.3.**  
**8**

THE POSITION OF THE BUMBLEBEE *BOMBUS TERRESTRIS* AMONG THE EUSOCIAL BEES

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Bumblebees are considered as primitively eusocial bees. *Bombus terrestris* belongs to the more advanced group of 'pollenstorers'. In this species the existence of queen-pheromones is shown. Recently, an other feature has been found: the queen also attracts workers in the nest, which form a kind of retinue. However, in spite of her pheromonal attributes a *Bombus terrestris* queen loses her control, and a part of the workers starts egg-laying. Some circumstances leading to this event are discussed. Moreover, a comparison with highly eusocial (i.e. honeybees) and more primitively eusocial bees (i.e. more primitive bumblebees and halictine bees) is presented.

510.3.  
9

### ASPECTS OF KIN RECOGNITION IN THE HONEY BEE (*APIS MELLIFERA*)

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It has been demonstrated under laboratory conditions that workers of the honey bee, *Apis mellifera*, can discriminate between full-sisters and half-sisters reared to the adult stage in the same hive. These results were obtained by assessing whether a bee introduced to a group of bees is bitten or stung. Here we present further data which demonstrates that:

1. workers habituated to half-sisters more readily accept strange half-sisters;
2. workers that have associated with half-sisters may become more acceptable when introduced to sisters of those half-sisters and less acceptable when introduced to their own full-sisters;
3. acceptance of a strange full-sister may depend on the number of full-sisters to which a bee is habituated;
4. discrimination between full and half-sisters occurs under red light (frequencies > 610 nm);
5. certain workers in a group are more predisposed than others to bite or sting introduced bees.

Data will also be presented from current experiments that address the question of whether an individual can use itself as a cue to assess its relatedness to a strange bee.

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### 510.3. 10 QUEEN-DOMINANCE AND THE CONDITION OF WORKER-LAID EGGS IN THE EUSOCIAL BEE, *Melipona rufiventris paraensis*

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The laying by workers in presence of the queen is a well known phenomenon of many stingless bees (Apidae, Meliponinae). The eggs laid by queenright workers of *M. rufiventris paraensis* were different from those laid by queenless workers. The queenright worker-eggs were more fragile through the incompleteness of the reticulate chorion. These eggs also had a defective micropyle. Probably, as a result of the incomplete chorion, these eggs had a high tendency to topple over on the surface of the liquid larval food, on which they were deposited in the broodcell. These eggs were ingested by the queen prior to her own oviposition.

The eggs laid by workers of a queenless colony had a similar structure as those laid by queens. These worker-laid eggs developed into males.



**S10.3.** SOCIAL ORGANIZATION IN AN ALLODAPINE BEE, EXONEURA BICOLOR  
**11**

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Exoneura bicolor is a univoltine, facultatively eusocial allodapine bee exhibiting varying degrees of caste differentiation. Several features of its social organization differ quite strikingly from patterns observed in halictines and indicate a unique strategy for coordinating foraging and reproductive roles. Although there is a slight overlap in adult generations, nests with brood contain adults of one generation only. In nests persisting for more than one year, primary egg-layers are distinguishable shortly after adult eclosion by relatively rapid cuticular tanning. Secondary egg-layers and non-reproductives, however, exhibit delayed cuticular tanning and remain in the nests throughout Autumn as unmated callows. Primary egg-layers forage for callow nestmates during Autumn, become mated, and start producing eggs in winter, whereas the remaining females mate in Spring and may produce a small number of eggs later in the season. This latter period of mating is reflected in persistence of adult males in nests for up to eight months. New nests are initiated by groups of up to six co-foundresses. Some aspects of caste differentiation are suggestive of "worker oppression", although the phenomenon of primary and secondary egg-layers can be understood as a trade-off between reproductive output and higher mortality rates associated with Autumn foraging.

**S10.4.** RELATEDNESS WITHIN AND BETWEEN COLONIES OF THE QUEENLESS ANT  
**1** RHYTIDOPONERA MAYRI.

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*Rhytidoponera mayri* is a large queenless ponerine ant living in prominent conical mound nests in the Australian arid zone. A small percentage of the workers mate and oviposit, but data from dissections indicate that many unmated individuals also oviposit. We studied a sample of about 100 nests over 3 years (the number declining probably because of drought) at a site near Broken Hill, N.S.W. We estimated relatedness within and between nests using data from four polymorphic allozyme loci and a multiallelic regression method. Although relatedness is low within nests ( $b = \text{ca. } 0.16$ ), there is statistically significant relatedness between nests according to whether they are nearest-neighbours or nests connected in a Gabriel-connected graph ( $b = \text{ca. } 0.05$ ). Autocorrelation analyses of principal component factor scores from the allozyme data reveal significant microgeographic heterogeneity in many instances.

**S10.4.**  
**2** COULD THE QUEENLESS ANT OPHTHALMOPONE BERTHOUDI RE-EVOLVE A  
REPRODUCTIVE CASTE FROM ITS FERTILE WORKERS?

CHRISTIAN PEETERS

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In the ponerine Ophthalmopone berthoudi the female reproductive caste has been lost and replaced by inseminated fertile workers. The differentiation of the reproductive cohort occurs during the short period of male activity. There are many unspecialized features in this reproductive system: small ovaries, large eggs, a substantial number of fertile workers which is not regulated, and a low rate of egg production per individual. The secondary emergence of a more sophisticated egg-laying caste is incompatible with a necessary compromise between worker and reproductive attributes. Indeed males mate with a small subset (genetically a random sample of the possible genotypes in the colony, since workers are born throughout the year) of all the ants born over a one-year period; thus most of the workers remain sterile and colony survival depends on their being effective nest labourers. A comparative study of the reproductive strategies in ten ponerine genera sheds light on the evolutionary transition between winged queens, ergatoid queens and fertile workers.

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**S10.4.**  
**3** REPRODUCTIVE SUCCESS OF QUEENLESS COLONIES OF APIS  
MELLIFERA CAPENSIS ESCH.

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In colonies of Apis mellifera, workers develop their ovaries and start laying eggs soon after they become queenless and no brood is available to rear new queens. Usually males develop from these worker laid eggs (arrhenotokous parthenogenesis). In Apis mellifera capensis, a honeybee which is abundant in a small area at the cape of southern Africa, the laying workers produce female offspring (thelytokous parthenogenesis). The question rises, under which selective conditions either arrhenotoky or thelytoky may result in a larger fitness.

Mendelian segregations in hybridization experiments showed that arrhenotoky and thelytoky in laying workers are linked to one single major locus. A one locus model regarding the risk of a queen loss, the number of drones produced by a queenless colony (arrhenotoky) and the probability of successful requeening of queenless colonies (thelytoky) proved useful to find out the reproductive success of either type of parthenogenesis. A high probability for queen losses favours the fixation of thelytokous parthenogenesis of laying workers.

**S10.4.**  
**4**

ECOLOGICAL GENETICS OF QUEEN NUMBER IN LEPTOTHORAX ANTS

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Starch gel electrophoresis of ant proteins provided information on genetic structure of L. longispinosus and L. curvispinosus populations. These data were utilized to estimate degrees of relatedness within colonies as well as between colonies for populations from Vermont, New York, and West Virginia. When coupled with information on colony fertility, the genetic data allow us to examine the efficacy of Hamilton's rule as a determinant of social evolution in general, and queen number in particular.

**S10.4.** GENETICALLY MEDIATED QUEEN POLYMORPHISM AND CASTE DETER-  
**5** MINATION IN THE SLAVE-MAKING ANT, HARPAGOXENUS SUBLAEVIS

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In the slavemaking European ant, Harpagoxenus sublaevis, queen polymorphism is controlled by a single locus with two alleles (E,e). Only homozygous ee-queens are gynomorphic (winged) specimens, while heterozygous and homozygous EE-queens are ergatomorphic. H.sublaevis is monogynous, the queens mate only once, and most of the colonies have ergatomorphic queens. With breeding experiments it could be shown that the E/e-locus (or another one closely linked to it) does not affect behavior or reproduction, but has a strong influence on caste determination. ee-larvae have a very high queen potential, eE-larvae and even more EE-larvae, however, can easier be determined to become workers. Thus, queen polymorphism apparently represents a side-effect of the two alleles, whereas selection preferably acts upon their caste biasing potential.

## 510.4. 6 ROLE OF WORKER THELYTOKY IN COLONIES OF THE ANT CATAGLYPHIS

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Thelytoky is not the rule in social insects. Cagniant demonstrated that, in the laboratory, queenless workers of Cataglyphis cursor can lay eggs which develop into workers and queens or males ; and a complete society is finally restored. Two problems were raised : is this phenomenon existing in natural conditions, and what is its adaptative value ? In the field we collected hundreds of colonies, but we never found solitary queens which could initiate a foundation as it is frequent for Lasius or Camponotus, but small colonies with a queen and a few tens of workers are not exceptional. In summer we observed that groups of workers can form temporary a separate nest near the principal nest with an important traffic between the two nests. We found also complete colonies (with a queen) separated only by one meter, which showed so many workers exchanges that they could be considered as a polycalic colony. We observed also that colony fission is possible in the laboratory. So we can hypothesize that thelitoky could be a mean to found a new colony, by a group of isolated workers, keeping momentarily strong relations with the mother colony.

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## 510.4. 7 THE INTERRELATIONSHIP BETWEEN MATING BEHAVIOUR, SEX RATIO AND QUEEN NUMBER IN FORMICA.

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Species and populations within Formica show large differences in the number of mated queens per nest, wich number may vary between one (monogynic species) and several hundred (polygynic species). A switch from monogyny to polygyny may occure within the same species and was observed to result in a male-biased sex ratio explainable through sib-competition between multiple queens. Our data are conflicting, however, because some other highly polygynic species regularly have strongly female-biased sexratios. We got a clue to the problem by comparing mating and dispersal behaviour. A model explaining evolution of polygyny by a queen-worker or worker-worker conflict forced by multible mating (polyandry) is tentatively suggested.

## S10.5. 1

### FORAGING BEHAVIOR OF AFRICANIZED BEES

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Africanized bees were individually trained in order to collect sugar syrup in one food source set at an analytical scale and 7 variables were measured. During the comparisons Africanized x Italian, results showed that the Africanized bees carry a load heavier than their own body weight, recruit more workers for the gathering and fly more rapidly. Comparisons Africanized x Caucasian showed that Africanized bees are lighter, transport less quantity of syrup and develop higher velocity of flight. Foraging behavior of  $F_1$  hybrids were also analysed and demonstrate the tendency of the descendants of the mating between Africanized with the European bees. In Africanized bees what influence the greater production of honey is the greater weight of the bee and the larger interval between the collections.

## S10.5. 2

### WINTER SURVIVAL OF AFRICANIZED AND EUROPEAN HONEY BEES IN CORDOBA, ARGENTINA

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An overwintering study of different sized honey bee colonies was conducted in the mountain valley of Cura Brochero, Cordoba, Argentina. Food consumption, population size, and survival were measured. A total of 80 colonies were involved, 40 of which were populated with about 1 lb. of bees per colony, and 40 with about 4 lbs. of bees per colony. Both size groups consisted of 20 colonies of Apis mellifera ligustica and 20 colonies of Apis mellifera scutellata Hybrids. The latter were chosen on the basis of a standardized aggressiveness test and were largely from swarms caught by beekeepers in zones known to have Africanized honey bees. All bees were sampled and their taxonomic status is presently under evaluation. The test site was selected for its special climatic conditions along the suggested southern limit of Africanized honey bees in Argentina. Wintering results and conditions will be reported.

S10.5.  
4

# MOVEMENT RULES OF HONEYBEES ON REAL AND ARTIFICIAL FLOWERS: THE LOCOMOTION TURNING THEORY

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Intra-floral search for nectar by honeybees (*Apis mellifera* L.) requires locomotion resulting in bee heading changes relative to arrival. Following intra-floral search bees do not re-orient themselves relative to their arrival heading as suggested by Pyke (1978) for bumblebees. Rather, honeybees move to the nearest flower edge, then fly directly to flowers most centrally located in their field-of-view (forward-moving-tendency). Therefore, changes in heading by honeybees between arrival and departure at flowers occur as by-products of intra-floral search. A movement rule and a timing rule sufficiently explain the bees foraging behavior.

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S10.5.  
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# BEHAVIORAL AND CHEMICAL APPROACH OF THE ROLE OF INTERSPECIFIC SEMIOCHEMICALS INVOLVED IN BEE-PLANT RELATIONSHIPS.

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Semiochemicals are mainly involved in pollinating insect and entomophilous plant relationships. We have particularly studied the role of aroma and nectar in honeybee-sunflower relationships. Hybrid seeds sunflower production is strictly dependent on foragers visits to both male and female parent lines ; but sometimes low seed yields seemed to be linked to a selective food choice of honeybees among the parent lines. In order to analyze the role of chemical parameters involved in bees attraction, we have set up comparative coupled behavioural and chemical experiments at field and laboratory levels, which led to :

- (i) an evaluation of foragers distribution upon several coupled parent lines.
- (ii) the "extraction" of a limited number of compounds considered as the "active fraction", sufficient for foragers to identify the whole sunflower aroma, and the determination of significant genetic qualitative and quantitative differences among the aromatic patterns of different sunflower genotypes.
- (iii) the determination of genetic variations among glucidic patterns of nectars and correlations between bees visits and glucidic spectra.

From a fundamental point of view such results led to a new insight concerning the identification of complex odorants by the bee. Moreover, from an applied point of view, such studies seemed to be useful for plant breeders in order to obtain a better control upon entomophilous pollination.

## **S10.5.** SOME ASPECTS ABOUT THE HYGIENIC BEHAVIOR IN HONEYBEES *Apis mellifera*.

**6**

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The hygienic behavior of honeybees has been known since 1936 as a resistance mechanism against American Foulbrood (AFB). This behavior consists of removing debris and dead brood. The hygienic behavior is probably controlled by two recessive genes, one responsible for the uncapping of cells containing dead brood (u/u) and another for the removal of these (r/r). However, many factors influence this behavior: brood/bee ratio, internal conditions of the colony (e.g., amount of honey, eggs, larvae and empty cells), nectar flow, age of dead brood as well as adult bees and, climatic conditions. Only the variable age of dead brood can be controlled in the commercial colonies and it is recommended that the age of the dead brood be 9 to 10 days old, because a lower coefficient of variations was obtained for hygienic behavior with this age class. It is necessary to obtain better information about laboratory measurements and the use of hygienic behavior as a resistance mechanism against other brood diseases. (CNPq/CAPES).

## **S10.5.** COMPARATIVE ONTOGENY OF BEHAVIOURS OF ITALIAN, AFRICANIZED, AND HYBRID WORKER HONEY BEES

**8**

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The weight, behaviour, and survival of worker honey bees from wild-type Africanized, Italian, and Africanized/Italian hybrid colonies in São Paulo state, Brasil, were compared in an observation hive colony headed by a hybrid queen. Each bee was weighed and marked immediately after emergence. Hybrid bees were intermediate in weight between the smaller Africanized and the larger Italian bees. However, they tended to live longer than either of the parental types. Italian bees were significantly shorter-lived than Africanized bees. The mean effective foraging life was 8, 10, and 12 days respectively for Italian, hybrid, and africanized bees. The mean weight of bees exhibiting "scouting" behaviour, observed as dancing, was significantly less than those which never danced in all three racial groups. A few bees <5%, apparently never foraged.

510.5.  
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AGGRESSIVENESS OF AFRICANIZED BEES UP TO DATE

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After the introduction of the african honeybees (*A.m.adansonii*) into Brazil in 1956 increased attention has been focused on the problem of bee aggressiveness and beekeeping in our country. The spread of the hybrids or Africanized bees has been relatively rapid. The occupied area is today from Argentina to Guatemala. The aggressiveness of *adansonii* and european bees was studied in details by our group. We concluded that the general nature of the aggressive behaviour in honeybees is the product of the interaction between their genetic composition and environmental factors. The temperature and humidity have a significant influence on this behaviour. The beekeepers in Brazil discovered how to handle the africanized bees and today many of them express a preference for those bees. The honey production is increasing and today the brazilian apiculture is considered very successful.

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510.5. DIVISION OF LABOUR BETWEEN HONEYBEE EYE-COLOR MUTANT WORKERS  
11

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Newly emerged workers of genotype By/by and by/by (Bayer=white eyes), Ch/ch<sup>li</sup> and ch<sup>li</sup>/ch<sup>li</sup> (lemon=yellow eyes), Ch/ch<sup>C</sup> and ch<sup>C</sup>/ch<sup>C</sup> (cherry eyes) were marked on the thorax and introduced to an observation hive. Behaviour observations were carried out in two periods (between 9-10h and 15-16h) during 32 consecutive days. Workers by/by developed all the activities concerning the division of labour except the waggle dance. The ch<sup>li</sup>/ch<sup>li</sup> workers did not perform all the activities executed by Ch/ch<sup>li</sup> females, but stayed in constant "reduced motivation phase", working without interruption. Only 3,7% of them established communication with the Ch/ch<sup>li</sup> workers, but apparently did not assimilate their message, even when it was repeated many times. We destroyed about 25cm<sup>2</sup> of the comb in order to evaluate the ability of construction by ch<sup>li</sup>/ch<sup>li</sup> workers, which spent 90% of their life repairing the comb, working since the third day after emergence until the last one. Ch/ch<sup>C</sup> and ch<sup>C</sup>/ch<sup>C</sup> did not attend the larvae and were unable to execute the waggle dance. The ch<sup>C</sup>/ch<sup>C</sup> workers did not collect nectar, pollen or water, and made cell polishing and operculum in a low degree.



**S10.5.**  
**12**

THE BEHAVIOR OF AFRICANIZED BEES WITH SPLIT STING  
MUTATION.

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An eye-color mutation called chartreuse-limão was obtained by applying gamma radiation to Apis mellifera workers. In subsequent crossings involving this mutation, we observed workers and queens unable to sting due to splitting of the sting parts. This new trait was called "split-sting" (SS). By a selection program, we were able to establish a lineage with 62% workers unable to sting. The workers exhibiting this mutation are perfectly normal in terms of behavioral and labor aspects involving feeding of brood, and making of wax and royal jelly. The split-sting workers have no venom in their sacs and do not respond to aggressiveness test when the alarm pheromone, isoamylacetate, is not released. However, when this pheromone is released, they participate normally in the attack although unable to sting. A thorough survey of workers descending from different Apis mellifera species and from workers collected in nature evidenced that this phenotype does not occur in these populations. The split-sting trait is associated with a type of cytoplasmic inheritance and is more easily transmitted through females than males. This new character may possibly be applied in the future to solve some of the problems associated with the excessive stinging by bees in Brazil, or elsewhere.

**S10.5.**  
**13**

FORAGE BEHAVIOR OF AFRICANIZED HONEYBEES

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Studies conducted on Leguminosae in Brasil have showed the great importance of the africanized honeybees in the pollination in natives or no natives species, such as: *Crotalaria juncea*, *Glycine wightii*, *Galactia striata* and *Dolichos lab-lab*. In *G. wightii*, one of the most important leguminosae for hay production in the tropical latitudes, observations showed high frequency of honey bees in its flowers in activity of nectar collection, with a mean of 16,15 flowers visited by minute. The results showed an increase of 55,8% in husks production and 44,7% in seed by husk production in flowers visited in relation to those not visited. The use of insecticides and the intensive harvest of wood have destroyed nests of native bees, resulting in some species of natives plants such as *Galactia striata* which has a low attraction for *A. mellifera*, problems in the husk and seed production. This fact rise the importance of honeybees and show the need of studies on methods that stimulate them to look for these specific plants. FAPESP, CNPq - PIG IV.

**S10.5.** BEHAVIOUR OF WORKER BEES (*APIS MELLIFICA* L.) AFTER  
**14** LICKING QUEEN PHEROMONES

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Worker bees which were given queen extract and no food afterwards lived on average 2 hours shorter than bees without queen extract. There was no relation between the life duration of bee, the quantity of queen extract in bee organism and the duration of licking. Food for worker bee after the receipt is an indispensable condition for survival because it radically changes the features of pheromone effect on worker bee organism. The licking of queen is immediately followed by receipt of food from other bees. Approximately 80% of worker bees that take part in food transfer ask or receive food from other bees. Appr. 20% of worker bees after licking the queen participate in food transfer and 80% visit honeycomb cells apparently leaving the licked pheromones in some of them. A bee colony has a reliable system of mechanisms suppressing the transmission of licked pheromones to other bees during trophallactic interactions. The effect of pheromones, licked from queen body, on bee behaviour is multiple, implying conversion of one form of pheromones into other. The conversion takes place in bee digestive tract, the process of licking included.

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**S10.5.** SENSITIVITY OF ODOUR RECEPTORS OF WORKER BEES (*APIS*  
**15** *MELLIFICA* L.) TO QUEEN'S PHEROMONES

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The results of the experiments carried out on June 18-20 and July 10-20, 1979 with worker bees of local population (medium-sized family with mated and laying queens) are presented in the paper. The sensitivity of their odour receptors to the queen pheromones has been determined by the EAG method. The queen extract in the quantity of 0.01 of its equivalent served as a pheromone source. It has been established that in summer about 20 % of worker bees of the medium-sized family of honey bees were in need of licking queen pheromones. The sensitivity of odour receptors of their antennae to the queen pheromones is higher than that of other worker bees. The lowest sensitivity of odour receptors to the queen pheromones was determined in those worker bees which licked them for several minutes. The stay of a worker bee in the vapour of the queen pheromones for 20 minutes did not decrease the sensitivity of odour receptors of the antennae to the queen pheromones.

**S10.5.** EVOLUTION OF SOCIAL BEHAVIOR IN STINGLESS BEES (HYM. MELI-  
**16** PONINAE).

RONALDO ZUCCHI

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Ribeirão Preto (SP) Brasil

The papers by Sakagami (1971) and Winston & Michener (1977) evidencing that the highly eusocial behavior of the Meliponinae and Apinae arose independently, enhance an excellent opportunity to study how supposedly divergent evolutionary forces culminated into comparable results. Mainly as an account of the lesser informations available for the stingless bees, a comprehensive behavioral comparison between both groups is actually somewhat hampered. In addition and specially in relation to the ethological aspects observed during the brood-cell oviposition process, an extreme inter-group diversity is being detected. The aim of the present communication is: 1. to evidence the behavioral diversity of the group; 2. to discuss the evolutionary trends related to specific aspects and 3. to summarise the available informations concerning the social regulation of the group.

**S10.5.** BEHAVIOR OF VIRGIN QUEEN IN STINGLESS BEES  
**17**

VERA LUCIA IMPERATRIZ-FONSECA

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References on virgin queens (Vq) behavior among stingless bees species have been made in same species, considering here both Trigonini and Meliponini. As in these eusocial bees it is impossible to the workers to rear a new queen when the physogastric queen dies, because of the mass provisioning practiced by stingless bees. It is necessary for the colony's safety to have surplus a Vq hatched or in imature forms. In Meliponini the observed gynes emerge from cells similar to those that produces workers, and are not attractive as they hatch. The life span of **Melipona's** depends on the general conditions of the colony, attractiveness of the physogastric queen and individual attractiveness showed by each queen. In Trigonini, where Vq are less abundant, special behavior toward Vq / developed: a) in some species Vq hatch very attractive, and are imprisoned by the workers in a cerumen structure, considering the territory of Vq and that can be opened by them to receive food or a court of workers. Imprisoned Vq complete her cycle and interfere on the colony rate of / oviposition, as observed in **Plebeia remota**; b) Vq can hatch without be attractive, and to / imprisoned some days later (**Schwarziana quadripunctata**); c) Vq can hatch without attractiveness / and have a voluntary prison in empty pots, (**Paratrigona subnuda**) untill complete their cycle.

**S10.5.**  
**18** QUEEN BEHAVIOR IN *Melipona marginata*

ASTRID KLEINERT-GIOVANNINI

DEPTO DE ECOLOGIA GERAL - IBUSP - SÃO PAULO

In all species belonging to the genus *Melipona*, the virgin queens hatch out of cells with the same size of that of the workers. Depending on colonies conditions, several queens are hatching at any moment. When they hatch, they are not attractive to the workers. Three or four days later, some can become attractive, / their abdomen increase in size and a court of some workers is formed around them. If the physogastric queen is old or/and less attractive than the virgin queens, the virgin queen establish her territory on the combs, defending it toward other virgin queens, the oviposition ceases and the mother queen can be killed by some workers. They first throw out her head and carry it, with the rest of the body, to a detritus area. Some hours later, it will be / carried out of the colony.

**S10.5.**  
**19** AERIAL DEFENSE OF THE NEST BY WORKERS OF THE STINGLESS BEE  
*Trigona (Tetragonisca) angustula angustula* (HYMENOPTERA:APIDAE)

WITTMANN, DIETER

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The stingless bee *T. angustula angustula* has a sophisticated defense strategy against flying insect predators at the entrance of its nest. Groups of worker bees hover on both sides in front of the nest entrance tube, facing a flight corridor leading to the nest. Intruders which enter this corridor are attacked by these bees from the side and from behind and forced to the ground by biting bees clinging to their wings. *T. angustula* is subject to predation by *Lestrimelitta limao*, a cleptobiotic stingless bee which performs organized raids on other nests to rob food supplies, larval provisions and nest constructing material. The presence of citral, released by *L. limao* during the raids, leads to a rapid increase in the number of hovering guard bees in front of *T. angustula* nests. This recruitment in response to citral suggests that the defense behavior in *T. angustula* has evolved under the pressure of *L. limao* raids and that citral functions in *T. angustula* as an alarm kairomone

S10.5.  
20

## SOCIAL REGULATION IN STINGLESS BEES

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The social regulation in stingless bees is controlled by behavioral, physiological and ecological factors that interact together and maintain the dynamic equilibrium in the society.

Population density fluctuations in the colonies (workers, males, and virgins queens) are related to some aspects, such as, availability of food (pollen and honey), queens oviposition, and physiological state of workers which are, mainly, related to glandular systems, egg production, and also, the coactions between workers and queen during the oviposition process.

The product of all those facts provide a complex social interaction in stingless bees society.

This approach is based on data carried out in several colonies of *Nannotrigona* (*Scaptotrigona*) *postica* Latreille, during many years, and compared with other species of stingless bees.

P10.-  
1

## HOMING IN FEMALES AND WORKERS OF POLISTES GALLICUS

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Females (foundresses and auxiliaries) of Polistes gallicus (L.) are able to assume a correct initial homeward orientation even if the landscape is hidden from view, and are able to home if displaced various distances (max 2 Km) from the nests (Ugolini 1981).

1- Initial homeward orientation is correct and independent of release distances and vision of landscape in both females and workers if the wasps are allowed sight of the sun, sky and landscape during displacement. Vision of landscape during displacement seems to play a role in orientation in females (Ugolini 1983) and workers. 2- Displacement in the dark at 1000 m does not influence the homing ability of females but that of the workers is very reduced. 3- Females and workers reared in cages with 2-4 hours flying experience over their surroundings are able to home from 1000 m. 4- Homing performances and homing times depend on release distances but workers show some differences with respect to females.

These differences could suggest that two or more different mechanisms are involved in the homing behaviour of P. gallicus.

P10.-  
2

## EFFECT OF AGE ON TROPHALLAXIS IN THE HONEY BEE

### APIS MELLIFERA CARNICA POLLMANN

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Food transmission from one bee (donor) to a group of 30 worker bees (receiver) of Apis mellifera carnica was studied. As initial food, 20 µl of sugarwater with methylene blue as a tracer was fed to the donor bee. Those bees fed significantly less on the age of 6-8 days. This was found for both the number of fed bees, and for the amount of food received by each fed bee and the whole group of 30 bees. Similar results were obtained when measuring the donor bee. The most food was found in bees 6-8 days old. The difference of summer and winter bees was only significant for the total food amount received by the fed group. The results show that the age of the donor bee has an effect on trophallaxis.

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## P10.- HOW TO SOLVE A LOGICALLY SIMPLE BUT MYCO-TAXONOMICALLY 3 WEIGHTY ENTOMOLOGICAL-MYCOLOGICAL PUZZLE?

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The unequivocal answer to the question whether the fungus cultivated by Macrotermitinae gives rise to a mushroom like Termitomyces or to Xylospheera nigripes (Ascomycetes) has remained a controversial subject for about 200 years. Once a connection between one of the two fruitbodies and the "spheres" (Aegerita Duthiei) abundantly encountered on the comb substratum could be established, the second one automatically passed as a contaminant due to the taxa concept in mycology. This led to a number of inconsistencies and even contradictions. Recent observations and experiments with the nest fungus of three Odontotermes species again confirmed the well known fact of a pure culture of A. Duthiei in their intact nests. The emergence of Termitomyces albuminosus from the "spheres" cannot easily be doubted or even denied because of too much evidence in its favour. On the other hand the regular and almost explosive appearance of X. nigripes cannot be traced to its mycelium already present in a freshly opened nest nor to its spores resting there or invading the nest during the opening procedure. In order to solve this puzzling phenomenon at least logically the following explanation is offered: At least one fruitbody exhibiting basidiomycetous characters and another one showing ascomycetous features originate from one and the same mycelium. Neither fungus need be nor is a contaminant. Therefore the binomials of these fruitbodies cannot be equivalent to those of animals and kormophytes. The nests of Macrotermitinae, among other fungus cultivating insects, can now be considered to be the source of fungal forms found outside their nests. Fungi emerging and spreading from these nests need not have evolved phylogenetically.

P10.-  
4

EVOLUTIONARY SIGNIFICANCE OF WORKER DOMINANCE BEHAVIOUR  
IN APIS MELLIFERA CAPENSIS ESCHOLTZ

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Queenless workers of A. mellifera capensis show dominance behaviour more clearly than other races of honeybees. The degree of dominance of worker bees can be measured by their trophallactic behaviour, ovary development, onset of oviposition and number of eggs produced. Dominance may be an indicator of individual fitness. It is shown that these characters are genetically determined, with estimated heritabilities ranging from .3 to .6.

As the tested behavioural and physiological traits are linked to a gene system, selection affects their frequencies in the gene pool. It is assumed that selection in natural populations of at least this race of honeybees operates at the individual worker level, too.

P10.-  
5

TAXONOMIC REVISION OF THE ANT GENUS *FORMICOXENUS*  
(FORMICIDAE, HYMENOPTERA)

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The nature of the ant genus *Formicoxenus* and the number of its constituent species are re-evaluated on the basis of old and new morphological and biological data. A xenobiotic life cycle, a regular production of intermorphs, and a regressive evolution of the males distinguish the genus in the family. It includes now seven species: two from Eurasia, *nitidulus* (Nylander) and *sibiricus* (Forel) nov. stat. & comb. (= *orientalis* Dlussky), and five from North America, *chamberlini* (Wheeler) nov. comb., *diversipilosus* (Smith), *hirticornis* (Emery), *provancheri* (Emery) nov. comb. and *quebecensis* Francoeur nov. sp. Among the latter four were traditionally associated to genera *Leptothorax* or *Symmyrmica*. The number of species and the most primitive forms support a nearctic origin for the genus *Formicoxenus* which invaded afterwards Eurasia where it further evolved.

**P10.-**  
**6** PLASTICITY OF RECRUITING BEHAVIOUR AMONG HONEY BEE FORAGERS AS A  
FUNCTION OF AGE.

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Honeybees recruiting behaviour upon a food source is a basic phenomenon of bee-plant relationships. This behaviour has been studied in controlled conditions, simulating the foraging situation and using an artificial flower device allowing to isolate chemical stimuli from visual parameters, chemicals (as aroma, nectar) being mainly involved in foraging behaviour.

In a first step, it has been shown that foraging was strictly restricted to a constant pool of the same foragers, when food source characteristics kept constant. When a choice is given between two equidistant food sources, equivalent in regards to the sugary reward, but providing two different olfactory stimuli, it appeared that recruited foragers seemed to be conditioned mainly to the food source location, more than to the quality of the olfactory stimulus associated to the food source.

In a second step, plasticity of foraging behaviour has been studied by setting up a whole colony composed of different identified classes of age. This experiment was considered as a reference in which the age of the youngest foragers, the length of foraging activity along bees life, the turn-over of the different classes of age were recorded. These results were compared to those of experiments set up with a colony of a single class of age, placed in conditions of forced foraging, in order to appreciate how bees are able to adapt their behaviour and to become foragers at an early stage.

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**P10.-**  
**8** CALCULATING THE LIFE EXPECTANCY OF WORKER BEES (*Apis mellifera*) BY MEANS OF THE EMERGING RATE AND THE NUMBER OF BEES

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Since conventional methods tend to yield figures that are too high for the median life expectancy of worker honeybees (*Apis mellifera*), three new methods are proposed. They are based on evaluating the emerging rate and the number of adult bees.

A) The bee curve integral corresponds to the number of bee days. The integral of the emerging rate curve gives the number of emerged adult bees. Under conditions of stability the ratio of these two integrals is a measure of life expectancy.

B) By subtracting the actual number of living bees from the growth curve we obtain the mortality curve. The distance between the two curves on the abscissa (time axis) corresponds to the median life expectancy of the bees.

C) The third method is based on the concept that mortality depends on the ranking age and not on the physical age of the worker bees. Whereas most of the youngest bees are considered for survival, they are disregarded with progressing ranking age until the number of observed bees is reached.



P10.-  
9

## NITROGEN BALANCE AND POPULATION DYNAMICS OF FREE-FLYING BEE COLONIES (*Apis mellifera*) IN SWITZERLAND

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Pollen collected by honeybees (*Apis mellifera*) is their main protein and nitrogen source. It is indispensable for brood rearing, for the nourishment of adult bees and for provisions.

On different bee yards throughout Switzerland pollen harvest and population dynamics are being studied. Considerable variation within as well as between bee yards has been found. In June, a pronounced gap in pollen supply is commonly observed in colonies situated north of the Alps. It is followed by a decline of brood area and number of worker-bees. In other colonies, however, esp. south of the Alps, pollen gathering reaches its maximum in June and July. Since these colonies also reduce their number of bees and brood-cells, no direct relationship of pollen-gap and colony decline can be demonstrated.

Because of the great differences between the colonies it is difficult to generalise the results obtained so far. On the other hand, we failed to confirm several of the conventional apicultural beliefs.

P10.-  
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## INFESTATION OF AFRICANIZED HONEY BEE DRONES, YOUNG HOUSE BEES AND MATURE FORAGERS BY THE MITE VARROA JACOBSONI

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The rate of varroa infestation was first compared in adult drone and worker of africanized honey bee colonies in Brazil. Drones had significantly higher rates of infestation. A second comparison was made between drones, young house bees (1 to 6 days old) and foragers (17 to 22 days old). The infestation rates were significantly different between the groups in the following order: drones > young workers > old workers.

P10.-  
11

A STUDY OF INFESTATION BY THE MITE VARROA JACOBSONI IN  
LAYING WORKER COLONIES OF APIS MELLIFERA

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It was determined that the Varroa infestation rate of laying-worker colonies was significantly lower than found in normal queen - right colonies. When mites were introduced with infested brood from a normal colony the infestation rate on adult bees increased temporarily and then rapidly decreased to a low level. Individual worker bees were much less often infested than those without having mature oocytes . Apparently the mites avoid workers with developed ovaries.



*Section 11 Conservation of Nature and Protection of Species .....*

R 11.1. *Population Changes and Conservation Strategies.....*

R 11.2. *Fauna Composition and Conservation in Man-Made Habitats .....*

**R11.1.** CHANGES IN DISTRIBUTION OF NETHERLANDS INVERTEBRATES,  
**1** WITH SPECIAL REFERENCE TO THE CARABIDAE (Col.)

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Nederlandse Entomologische Vereniging<sup>2</sup>

Distribution and abundance of invertebrates in the Netherlands is investigated within the framework of the European Invertebrate Survey (E.I.S.). The distributional data of the computerised data base are used for e.g. biogeographic investigations. Changes in distribution and abundance of taxa during this century are analysed with advanced computer programs.

The Carabidae project (H. Turin) was set up to investigate whether species with a poor dispersal power have suffered more during this century than species with a better dispersal power. This hypothesis is based on the established trend in surface decrease and isolation of several habitats (woodlands, peat moors) by human activities during this period and the supposition that the rate of re-establishing after local extinction is correlated with the dispersal power of the species.

The results of these studies are used to advise the authorities on the improvement of purchase policy and management of nature reserves.

**R11.1.** A review of the conservation of New Zealand's insects  
**2** and other terrestrial and freshwater invertebrates

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The publication of the New Zealand Red Data Book in 1981 with a complete absence of invertebrates might suggest that none were endangered species. This inference is not justified as we illustrate with some representative examples. The legislation covering the conservation of invertebrates is also reviewed and case histories of some specific examples are discussed.

### R11.1. REPORT ON THE "RED BOOK" OF IBERIAN ORTHOPTERA

3

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This report announces and gives preliminary results of a study underway on scarce or rare, endemic Iberian Orthoptera. The text follows, as far as possible, the system of the IUCN "Red Data Books". The authors stress the biogeographical importance of the Iberian Peninsula, and the characteristics of its orthopteroid fauna. The objectives of the "Red Book" and the criteria followed to qualify a species for inclusion are discussed. There follows a preliminary list of species with comments on their distribution as well as bionomic and ecological data. A bibliography of more than twenty titles completes the paper.

### R11.1. NOTES ON LEPIDOPTERA CONSERVATION IN SPAIN

4

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The authors announce the preparation of a second edition of their Red Book of Iberian Lepidoptera on the basis of research carried out since the first edition. Six species of Rhopalocera, mostly endemics, have been excluded in view of the recovery of their colonies: Plebicula nivescens, Lysandra caelestissima, Agrodiaetus fabressei, A. ripartii, Erebia zapateri and E. palarica. Moreover, owing both to bibliographical criticisms and to their confirmed extinction, three other species have been excluded: Samia cynthia, Antheraea pernyi and Coenonympha oedippus. Several other taxa, both at specific and subspecific level, have changed status and Agrodiaetus violetae is included. Some concluding remarks are made on conservation policy in Spain with particular attention to the problems posed by the new quasi federal Spanish state composed of autonomous regions.

## R11.1. 5

### INSECTS AND ENVIRONMENTAL PLANNING IN THE STATE OF CALIFORNIA, UNITED STATES OF AMERICA

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We will summarize the laws, governmental agencies and private organizations that protect endangered insects in California. The specific effects of insects in the planning process at two sites will be discussed: San Bruno Mountain (SBM) on the San Francisco peninsula and Ballona Creek (BC), a coastal salt marsh in Los Angeles County. SBM is inhabited by 2 butterflies designated by the federal government as Endangered Species. Considerable time and funding were spent in developing a plan that will allow development of portions of the site and protect and manage the insects as well as their habitat. At BC, insects played only an indirect role in the formulation of the land use plan. Several species were used to delineate areas of significant value in and around the salt marsh. Finally, four recommendations for more effective protection of endangered insects in California are presented. First, a list of species that are or soon will be threatened with extinction should be compiled. Second, the state of California should extend endangered insects the same legal protection given to vertebrates. Third, sources of funding should be made available to qualified scientists to investigate the biology and ecology of these animals. Fourth, information sheets on the insects, perhaps based on the IUCN RED DATA BOOK format, should be written and distributed to urban planners, wildlife managers and other concerned parties.

## R11.2. 1

### THE STRUCTURE OF PIONEER ANIMAL COMMUNITIES IN MAN-MADE HABITATS AND CONSEQUENCES FOR SPECIES CONSERVATION

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Within man-made habitats of early successional stages in Southern Germany the structure of animal communities was investigated with regard to substratum (sand, clay, gravel), ground structure, humidity, plant communities, vegetation coverage and others. More than 400 species of dragon-flies, grasshoppers, bees, waterbugs, beetles, amphibians, reptiles and small mammals were taken into account but most of the quantitative conclusions refer to carabid beetles. The type of substratum substantially contributes to the local structure of the animal communities. Number of species and species diversity of Carabidae rise with increasing vegetation coverage, reaching a maximum at a coverage lower than 60 per cent, but decline again when coverage is higher (later successional stages or ruderal vegetation on rich soils). For Carabidae, Apidae, Orthoptera and Amphibia percentage of rare and threatened species (both species number and abundance) is highest where vegetation coverage is lower than 20 per cent. Diversity of Carabidae is correlated with structural complexity of the habitat. Typical component communities from bare riverbanks, marshland, sand dunes and not intensively cultivated agricultural landscapes immigrate into those secondary habitats. Consequences for species conservation and habitat management are discussed.

**R11.2.** THE SUCCESSION OF CARABID AND SPIDER COMMUNITIES IN A CHARCOAL  
**2** MINING AREA AND THE INFLUENCE OF DIFFERENT AFFORESTATION PRACTICES

H.-J. MADER

The natural succession of the epigeic carabid and spider communities on the bottom of a charcoal mining site was investigated during 14 years (1968 - 1982) by means of randomly distributed pitfall traps. The study site being enclosed by a fence and free of human interference. During the last four years the species composition was compared with that of neighbouring afforested areas.

The distribution of pioneer species in space and time is analysed. The ecological structure changed from an early pioneer association followed by transitional stages to an woodland association. Structural changes depend on different afforestation practices.

Island habitat characteristics regarding isolation and the dynamic equilibrium of species are discussed in view of nature conservation.

**R11.2.** ANALYSIS OF *CARABIDAE* POPULATIONS (COL.) ON DIFFERENTLY  
**3** MANAGED ROAD VERGES AND ITS SIGNIFICANCE FOR CONSERVATION

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The ecological structure of ground beetle populations (Coleoptera: Carabidae) of six (in 1983: eight) rural road verges in Westfalia (FRG) was investigated for four years (1980-1983) by means of pitfall traps. Three (four) of the sites were exposed to high environmental stress by roadside management (frequent and untimely mowing) and traffic, whereas the other three were only slightly stressed. Diversity of vegetation structure showed a distinct response to the different types of management and led to clearly correlated differences in the composition of the epigeic fauna. The population structure of Carabidae proved to be a sensitive indicator for the favour of environmental conditions to the fauna. This is shown by the ecological parameters of species diversity, faunistic overlap, dominance structure, species composition, presence of specialized species, and the different predominance of eurytopic or stenotopic species. Responsible management of road verges may decisively contribute to make them a refuge for a fauna of surprising complexity.



**R11.2.** THE DECLINE OF BLISTER BEETLE POPULATIONS (COLEOPTERA:  
**4** MELOIDAE) IN FINLAND

P E K K A N U O R T E V A:

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The fate of the populations of Finnish meloid beetles was investigated on basis of material existing in the collections of 9 museums and 44 private entomologists (762 specimens) and on basis of a questionnaire sent to entomologists. It was noted that the decrease of the populations started during the decade 1951-60, reached the minimum during the decade 1961-70 and showed a very slight recovery during the last years. The populations of Apalus bimaculatus L. and Meloe brevicollis Panz. have completely died out, the last specimens were taken in 1926 and 1957 respectively. The population of M. proscarabaeus L. has continuously decreased and has disappeared from the western part of the country. M. violaceus Marsh. has it too practically disappeared from the western part, but the decline of the population has been only slight. The decline of the meloid populations coincided with an increase in car traffic and to decrease in July temperatures (time for triungulids for all species except M. violaceus), but not clearly to the use of pesticides. Forest plowing in clearcut areas seems to be responsible for the recent population recovery. - A preliminary report has been published in Finnish (with english summary) by P. Nuorteva, E. Tulisalo, B. Larsson, A. Lehtinen, M. Nummelin, A. Ojala & K. Yrjönen: Suomen touko-härkäkantojen romahtaminen. Luonnon Tutkija 87:84-95, 1983.

**R11.2.**  
**5** Effects brought about on the fauna of the Kaiserstuhl, due to the use of controlled burning on its vineyard slopes - problems, first results

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The Kaiserstuhl, located near Freiburg, covers approximately 100 km<sup>2</sup> of loess-covered volcanic mountains. It's faunal, floral and geological conditions are unique to middle Europe.

The change from less profitable cattle keeping to an intensive cultivation of grapes brought with it the replacement of a previous cutting of the vineyard slopes for fodder production to a method of controlled burning. Controlled burning is regarded by the vineyardists as the only practical method of preventing the unwanted accumulation of plant material. A 1975 Baden-Württemberg law prohibits controlled burning, despite this the practise is continued. The consequences of controlled burning for the nature reserve are regarded as dangerous for the animal life, especially because of the vineyard slopes are important refugiums in the intensively cultivated land.

Our present investigation aims to show the effects of controlled burning on the fauna of the vineyard slopes. Temperature recordings were made during the controlled burnings. We seek to determine the direct effects of the heat on selected animals in different strata and the indirect effects on the animals as far as the character of the zoocoenose is changed from burned to unburned (control) areas.

Section 12    *Agricultural Entomology* .....

R 12.1.    *Biology of Pests* .....

R 12.2.    *Ecology and Population Dynamics* .....

R 12.3.    *Influence of Agricultural Practice* .....

R 12.4.    *Host Plant Resistance* .....

R 12.5.    *Crop Losses* .....

R 12.6.    *Mass Rearing and Biotechnology* .....

R 12.7.    *Survey and Forecast* .....

R 12.8.    *Integrated Control* .....

R 12.9.    *Extension* .....

R 12.10.    *The Professional Entomologist* .....

S 12.1.    *Symposium on the Colorado Potato Beetle (*Leptinotarsa decemlineata*)* ....

S 12.2.    *Bemisia tabaci – Ecology and Control* .....

S 12.3.    *Floricultural Entomology* .....

P 12.1.– .....

P 12.6.    .....

R12.1.  
1

## THE BOLL WEEVIL: A NEW MENACE TO COTTON PRODUCTION IN BRAZIL

S. BARBOSA<sup>1</sup>, M.J. LUKEFAHR<sup>2</sup> AND R. BRAGA SOBRINHO<sup>2</sup>

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The boll weevil (Anthonomus grandis) Boheman, Coleoptera: Curculionidae) is the most important single pest of cotton. It was first detected in Brazil in February of 1983 around Campinas in the State of São Paulo. Six months after it was found some 2,000 miles away in an isolated area bordering the northeastern States of Paraíba and Pernambuco. The attempts for eradication are discussed and an account of the losses caused on Brazilian cotton production since its introduction into the Country is given. The spread of the insect throughout Brazil is chronologically presented in a map. Projections are made on the future impact this new pest may cause on the two widely different cotton production systems practiced in Brazil.

R12.1.  
2

## SCARABAEIDAE AND ELATERIDAE (COLEOPTERA) OF AGRICULTURAL SIGNIFICANCE IN PACIFIC ISLANDS

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Islands discussed are Fiji, Tonga, Niue, Samoa, Cook Islands, Tuvalu and Kiribati, with comparative references to other islands in the southwest Pacific.

On atolls and other islands where Cocos nucifera is the main crop, the most serious actual or potential pest is the rhinoceros beetle Oryctes rhinoceros. Field crops are subject to attack by a wider range of scarab and elaterid pests. On most islands and crops, the rose beetle Adoretus versutus is the most damaging of these. Wireworms can cause serious damage to sugar cane in Fiji, and have also been implicated in damage to roots of other crops.

Relatively little work has been done on soil-dwelling larvae in these islands, and at present it is difficult to assess the significance of some species found under crops. Some wireworms (Conoderus pallipes) are probably primarily predators, and some white grubs (e.g. Oxycetonia versicolor) probably feed mostly on dead plant material.

**R12.1.**  
**3** THE NOXIOUS WHEAT APHID DIURAPHIS NOXIA (MORDWILKO) :  
A NEW MAJOR PEST IN SOUTHERN AFRICA

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The noxious wheat aphid appeared in the central region of the Republic of South Africa in 1978. By the end of 1979 it had spread to all the major wheat producing areas of southern Africa. It can cause severe losses on dryland winter wheat in the summer rainfall region but infestations do not reach damaging levels in irrigated wheat or in the winter rainfall region. It oversummers on volunteer wheat and Bromus grass species. The wheat crop, which is planted in autumn, is colonised by apterae and alatae from summer hosts. Apterae appear to play a major role in further distribution within the field. The infestation increases from 5% in June to 90% infested plants in late October. The increase follows a natural logarithmic curve and early observations can be used to make population predictions. Initially migration is horizontal but later in the season as the halms develop it is vertical. Most damage is done between growth stages 32 and 59. A single spray at growth stage 31 frequently precluded the necessity of further control measures. The symptoms of attack viz white, yellow and purple streaking and rolling of the leaves are caused by a toxin injected during feeding.

**R12.1.**  
**4** *ZYGINIDIA* INFESTING MAIZE IN ITALY

C. VIDANO and A. ARZONE

The 10 species of *Zyginidia* (Homoptera Auchenorrhyncha Typhlocybinae) found in Italy live usually on well known wild graminaceous plants growing in natural ecosystems or in uncultivated areas. At least 7 of them can invade cultivated graminaceous plants and especially *Z. mays* which appears particularly attractive for *Z. pullula* in northern Italy, *Z. ribauti* in central and southern Italy, *Z. lineata* in Sicily and Sardinia, and *Z. scutellaris* in Sardinia. The presence on maize of other species, such as *Z. italica*, *Z. longicornis* and *Z. servadeii*, is more localized. Further 3 species, *Z. adamczewskii*, *Z. mocsaryi* and *Z. serpentina*, were not yet found on maize. Symptomatic dechlorophyllations, due to the trophic activity of nymphs and adults, characterize the leaves of the involved plants. This phytopathological problem is reduced by an egg parasite, *Anagrus* sp., and several fungi, among which *Cladosporium cladosporioides*, *Penicillium oxalicum*, *Fusarium oxysporum*, *Mucor hiemalis*, *Drechslera ravenelii*, *Verticillium lecanii*, that seem to be very efficient against *Z. pullula*.

**R12.1.** PIERID CATERPILLARS AS SERIOUS PESTS OF TWO ECONOMICALLY  
**5** IMPORTANT LEGUMINOUS PLANTS IN KERALA

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(Department of Zoology, University of Calicut, 673 635,  
India)

Pest attacks observed early in 1982 on two highly economically important species of Cassia grown in Kerala and consequent destruction of a large number of plants of varying age prompted us to undertake this investigation. The severity of the attack was so intense that out of the 1150 plants grown in and around the Calicut University Campus, only 92 survived. Even these showed symptoms of serious attack when the investigation was started. Results of the extensive field studies when compared with those of laboratory observations revealed that two species of Pieridae, Anapheis aurata and Catopsilia pyranthae? are serious pests of Cassia fistula and C. javanica respectively. On several occasions on each plant several hundreds of eggs and larvae of different stages could be simultaneously located. Under laboratory conditions, the egg had an incubation period of 4-5 days followed by 5 larval instars, each ranging from 3-6 days, finally leading to the chrysalid stage passed in 6 days. Although over 95% emergence could be recorded in the laboratory, the mortality rate was very high under field conditions due to heavy rain and strong wind. Introduction of two species of predatory ants proved as effective agents of biological control of these pests.

**R12.1.** FRUIT FLY (DACUS DORSALIS HENDEL) INCIDENCE/ACTIVITY IN  
**6** GUAVA, MANGO AND PEAR ORCHARDS IN PUNJAB

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Fruit fly (Dacus dorsalis Hendel) incidence in the guava fruits was highest in the Central zone (a plain area) than the Sub-mountain zone (comparatively colder region). Higher percentage of guava fruits were infested by the fruit fly in the mixed (guava block within/surrounded by citrus, pear, peach, mango, plum, loquat, jaman and few other type of fruit tree's blocks) orchard (41 per cent), followed by partially mixed (guava orchard within/near mango/citrus/peach orchards) orchards (18 per cent) and isolated orchards (13 per cent). Among the 8 guava cultivars (Apple, Strawberry, Red Flesh, Allahabadi Sufeda, Lucknow 49, Seedless, Pink Flesh and Banarsi), Red Flesh and Seedless cultivars had the lowest larval counts/egg puncture/kg fruit. In these guava cultivars, there was no difference in larval counts per egg puncture even when there were up to 9 egg punctures per fruit. In Dusheri Mango orchards, the period of maximum adult activity on the fruits was during 11 h and 12 h observations, while the observations were taken from 9.00 h to 17.00 h at hourly intervals. Pupal counts revealed that there was 30.77, 65.00 and 87.50 per cent fruit infestation in Dusheri Mango, Sucking Mango and Chausa Mango. Among the pear cultivars (Leconte, Baghugosha, Smith, Kieffer and Patharnakh), Kieffer had the lowest egg puncture counts, lowest larval/pupal counts per kg fruit and lowest percentage of fruit infestation.

**R12.2.** ECOLOGY OF BROWN PLANTHOPPER (NILAPARVATA LUGENS, STÅL)  
**1** DURING THE WINTER SEASON IN TAIWAN (R.O.C.)

CHU, YAU-I DEPARTMENT OF PLANT PATHOLOGY AND ENTOMOLOGY, COLLEGE OF AGRICULTURE, NATIONAL TAIWAN UNIVERSITY, TAIPEI, TAIWAN (R.O.C.)

Through the inoculation test, brown planthopper (BPH) is recognized as a monophagous insect. Paddy plant including ratoon paddy is the only host plant which can complete its normal development.

There is 2 to 3 months of paddy vacant season in Taiwan. It is variable with northern, central and southern districts, while almost falls on November to March. During those seasons, BPH apparently feed on ratoon paddy and pass the winter. Due to the low temperature, in those three months, BPH complete only 1 generation in northern district. The mortality of BPH in winter is very high. Till the end of March, the population is reduced to 5-40 percent of December. It is almost corresponding to the density of 1 hopper per 100 paddy stubs. However, it is the sufficient initial density to induce serious damage on the first crop of paddy until its harvest.

**R12.2.** POPULATION AND DISTRIBUTION PATTERN OF PARLATORIA  
**2** ZIZYPHUS (LUCAS) IN CITRUS ORCHARDS IN EGYPT

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NATIONAL RESEARCH CENTRE, CAIRO

The population and distribution pattern of the black parlatoria scale, Parlatoria zizyphus (Lucas) have been investigated. This scale has two annual peaks of abundance in September and May. It passes through three annual generations, the first in September-October, the second in March-April and the third in June-July on grape fruit trees. The build up of insect population on different zones of grape fruit trees in different seasons of the year was studied. The insect distribution of different insect items are significantly affected at different heights and directions of the trees. The highest population tend always to be accumulated on the lower and middle shady zones of the trees in different seasons. With regard to directions the central core of the tree harboured the highest population followed by the west direction and the lowest population was accumulated on the north or south direction in the fall and spring. In summer, the highest population settled on the south direction in contrast to the east or north directions which harboured the lowest population. This mode of distribution was discussed in correlation with the environmental conditions.

**R12.2.** VEGETATIONAL DIVERSITY AND COLONIZATION OF COLLARDS BY APHIDS  
**3** AND THEIR PARASITOIDS

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<sup>1</sup>Department of Entomology, Ohio State Univ., Columbus, Ohio USA

Collards were planted into weedy, mowed, or tilled plots in Ohio and California, USA. Populations of Myzus persicae and Brevicoryne brassicae were highest on larger collards and where weeds were tilled. Primary parasitism (mostly by Diaeretiella rapae) was greatest where weeds were untilled but mowed. Secondary parasitoids were most numerous and diverse where weeds were tilled and collards were surrounded by bare soil. The complex of secondary parasitoids was dominated by Asaphes lucens and Aphidencyrus aphidivorus in Ohio and by Alloxystidae in California. This may be due to differential overwintering survivorship.

**R12.2.** INTERRELATIONS BETWEEN SOIL-INHABITING COLLEMBOLA  
**4** AND PATHOGENIC SOIL FUNGI IN SUGARBEET

B. U L B E R

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Collembola, particularly Onychiurus spp., may affect sugarbeet emergence by feeding. They can also consume soil fungi and show a preference for some pathogens which cause damping-off. By feeding on these fungi fungus infection of seedlings as well as attack of Collembola against seedlings in the soil may be reduced. In two field trials with a high initial population density of Onychiurus spp. and a high infestation of pathogenic fungi, particularly Pythium spp., populations of Collembola and/or fungi were manipulated by application of insecticides and/or fungicides and by release of laboratory-reared O. fimatus. Emergence, feeding injuries and fungus infection of sugarbeet seedlings were assessed. The results obtained in the field were confirmed by pot experiments. No evidence was found that O. fimatus is able to transmit P. ultimum to uninfected beet seedlings.

R12.2.

5

ECOLOGY OF HELIOTHIS ZEA AND H. VIRESSENS (LEPIDOPTERA:NOCTUIDAE)  
AS REVEALED BY LONG TERM BLACK LIGHT TRAPPING.

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Twenty years of black light trapping of Heliothis zea and H. virescens at a central location in the intensively farmed flood plain of western Mississippi reveal the following concerning the ecology and population dynamics of these species:

- 1). There is no evidence for competition (or any other interaction ) between them.
- 2). Intraspecific, density dependence does not appear to be important in the population dynamics of either species.
- 3). Rates of increase of H. zea are higher than for H. virescens (which are near replacement rate early in the year).
- 4). The phenological relationship between cotton fruiting initiation and moth flight does not affect rates of increase of either species.

R12.2.

6

PARASITE AND PREDATORS OF POLYPHYLLA OLIVIERI CAST . IN IRAN

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White grub is one of the most important pests of orchards in Iran . It is a native pest which is distributed in most parts of the crop growing areas in Iran . The ecology and natural enemies of this pest has been studied. Its parasites and predators have been indicated as following :

A- parasite : we have found a species of Tachinid fly in important agricultural cities of Iran . Its scientific name is Microphthalma europaea and the percent-

age of parasitism is until 20%.

B- predators - some of the animals prey this pest , they are as follows:

1- Birds : the most important of them are: rook (Corvus frugilegus) , carrion crow (C. coronae L . ), magpie (Pica Pica ) and Larus argentatus

2- Cats : they are active predators of adult insects.

3- Dogs : they act like cats , but are less active

4- Wild pigs : we have studied the activity of this predator in every orchards near the forests.



**R12.2** SEASONAL ABUNDANCE OF CHRYSONPHALUS FICUS, WITH SPECIAL  
**7** REFERENCE TO ITS PARASITES, ON PALM TREES (HOMOPTERA,  
DIASPIDIDAE)

ATEF G. ALY

Plant Protection Institute, Ministry of Agriculture, Egypt.

Counts were made for all the scale stages, as well as for its parasites, throughout one year at 15 days intervals.

Results are represented in a graph where the numbers of both scales and parasites are plotted against dates. It shows that the scale has three generations a year, two big ones in Spring, and a smaller one at the beginning of Fall.

The graph suggests that any chemical control should be limited to early spring or better at the beginning of Fall where the population density of the pest is still high while the parasites become relatively low.

**R12.2** Population Dynamics of the Sugarcane Borer, Diatraea  
**8** saccharalis (F.), in Cuba.

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Research Institute of Plant Protection, Havana, Cuba

Population dynamics of Diatraea saccharalis (F.) was studied in different sugarcane areas of Cuba during three years (1980-1983). Temperature from 23 to 29 °C, relative humidity from 71 to 85 %, rainfall from 0 to 100 mm, and plant age from 3 to 9 months were the best conditions for the pest development. The tachinid fly Lixophaga diatraeae (Townsend) was the most efficient natural enemy, with parasitism levels from 10 to 70 %. Pest population was positively correlated with temperature and plant phenology. Parasite density was also positively correlated with pest population.

R12.2.

9

VARIATIONS IN TEMPERATURE REQUIREMENTS OF POSTDIAPAUSE  
DEVELOPMENT IN OSTRINIA NUBILALIS

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Temperature requirements after hibernation (day-degrees above 9°C from the end of the winter to the emergence of the moths) of Corn Borer larvae varied from year to year and differed between two populations from sites with different climate. The eventual causes and the eventual effect on population dynamics are discussed.

R12.3. EFFECTS OF INTERCROPPING ON PEST AND PREDATOR COMMUNITIES IN MAIZE-  
1 FORAGE AGROECOSYSTEMS

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Arthropod density and species composition were compared in mono- and polyculture maize (Zea mays) and alfalfa (Medicago sativa) systems. Corn pests, Diabrotica, Ostrinia, Agrotis, density and damage levels, differed between intercropped and non-intercropped corn. Predator numbers - primarily carabid and staphylinid beetles and spiders, and activity levels were greater in intercropped versus monoculture corn systems. These results will be discussed within a general paradigm for intercropping considering both entomological and agronomic phenomena.

12

## **R12.3.** INTERACTION BETWEEN ACIDIC PRECIPITATION AND ARTHROPODS **2**

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Greenhouse populations of European corn borers (*Lepidoptera*: *Ostrinia nubalis*) and armyworm (*Pseudaletia unipuncta*) were subjected to three levels of simulated acidic precipitation: control (pH 5.6), ambient acidity for Ohio (pH 4.2) and pH 3.5. Corn pest larvae were placed on corn plants which were grown in large caged containers. Plant height, yield, nutrient content and consumption were measured on corn plants. Larval weight, head capsule size, time of development, population size, and mortality were measured on insects. Results of these experiments will be presented and discussed in terms of biological stress effects on corn (maize).

## **R12.3.** THE INFLUENCE OF MINIMAL CULTIVATION AND DIRECT DRILLING ON PEST PROBLEMS IN CEREALS **3**

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The relative severity of attack by pests and the size of populations of pest predators were assessed regularly in cereal crops that had been either direct drilled, minimally cultivated or ploughed for a number of years. These assessments were made annually on three long-term experiments for up to 8 years, on 16 ADAS experiments that compared ploughed with direct drilled cereals for more than 5 years and in a 3-year survey of 7 ploughed fields and 7 direct drilled fields on a farm in Sussex.

Attacks by wheat bulb fly (*Leptohylemyia coarctata* Fall.) were absent from direct drilled crops and attacks by frit fly (*Oscinella frit* (L.)) and other dipterous stem borers were extremely low compared with those on ploughed soils. This was attributed to the burying of predators and parasites of these pests by ploughing.

Attacks by slugs (especially *Agriolimax reticulatus* Mull) were invariably much greater in direct drilled soils than ploughed ones, as were attacks by leather-jackets (*Tipula* spp), wireworms (*Agriotes* spp) and chafers (especially *Phyllopertha horticola* L.).

In general, direct drilling favoured the activity of surface predators such as carabid and staphylinid beetles. Overall pest problems tended to be less in direct drilled than ploughed crops.

**R42.3.** CHANGES OF ECONOMIC IMPORTANCE OF MAJOR INSECT PESTS OF  
**4** VEGETABLES AND PROSPECTS FOR THEIR CONTROL IN TAIWAN

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Since 1945, shifting agricultural ecosystem, economic structures and social demands has resulted in significant changes of the economic importance of major insect pests of vegetables in Taiwan. A detailed discussion of the procedures for assessing the importance and tracing the shifts of insect pests of vegetables is given in the present paper. In addition, fully speculated and assessed in this article include the effects of possible causes for these shifts, such as an increase of the number of kinds and varieties of vegetables grown, expansion of areas and regions for vegetable culture, adjustment of grown seasons, lengthening of supply period, yield increase per unit production resources, growing summer vegetables in mountainous areas and the uses of pesticides. This paper has made an overall review of the chemical control of vegetable insect pests as well as the pleas to plant protection personnel, including researchers, reviewing board, extension staff and users of pesticides to focus their attention on the safety of pesticides, to strengthen research on non-chemical methods, to search for means of decreasing reliance on pesticides, and to implement integrated pest management programs.

**R42.3.** ENVIRONMENTAL MANIPULATIONS AS AFFECTING POPULATIONS OF THE  
**5** SUGARCANE BORER

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Cultural practices enhancing arthropod predation on the key sugarcane pest, Diatraea saccharalis(F.), include crop ratooning and the encouragement of minor weed infestations (sub economic threshold), particularly of annual grasses hosting alternate food for Solenopsis invicta BUREN and other predators. Though 3-fold differences in susceptibility exist among commercially grown varieties in La., the moderately resistant CP65-357 has provided substantially the greatest pest reductions.

Recent increases in D. saccharalis occurred largely from new highly susceptible varieties and production of alternate host crops. Three times the production of D. saccharalis pupae and adults/ha of sugarcane is produced in sweet sorghum through the manipulation of planting and harvesting schedules for energy alcohol.

**R12.4. DEVELOPMENT AND SURVIVAL OF FRUIT BORER, HELIOTHIS ARMIGERA (HUBNER)**  
**1 ON BORER RESISTANT AND SUSCEPTIBLE TOMATO GENOTYPES**

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Development and survival of tomato fruit borer, Heliothis armigera (Hubner) (Noctuidae: Lepidoptera) was studied on six tomato genotypes - two pest tolerant (HT64 and HT50), two susceptible (HS172 and HS173), one recommended variety (HS101) and one wild tomato species (Lycopersicon hirsutum f. glabratum) at a constant temperature of  $29 \pm 1^{\circ}\text{C}$ . The duration of different developmental stages on different tomato genotypes varied from 37.5 (HS173) to 41.6 (HT64) days. On L. hirsutum f. glabratum, the oviposition period of the insect could not be determined as the moths died soon after emergence. The duration of larval + pupal period on this wild species was 34.6 days. The larval survival varied from 16.6 per cent (L. hirsutum f. glabratum) to 90.0 per cent (HT172 and HT173).

**R12.4. SOME MORPHOLOGICAL AND BIOCHEMICAL PLANT CHARACTERS IN**  
**2 RELATION TO SUSCEPTIBILITY OF TOMATO TO FRUIT BORER,**  
**HELIOTHIS ARMIGERA (HUBNER)**

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Effort has been made to correlate the resistance in tomato to fruit borer, H. armigera with various plant characters. The morpho-biochemical characteristics determined were: fruit yield per plant, number of flowers per inflorescence, number of fruits per truss, number of fruits per plant, size and roughness/smoothness of calyx, size and shape of the fruit, vine, size, pericarp thickness, number of locules per fruit, nitrogen, phosphorus potash, sodium, total crude protein, zinc, iron, copper, managanese, total chlorophyll, chlorophyll 'A' and 'B', total phenols, dry matter content, ash, acidity, ascorbic acid and reducing sugars.

Infestation on number basis was positively correlated with infestation on wight basis. Infestation, both on number and weight basis was negatively correlated with number of flowers per inflorascence. Roughness/smoothness of calyx was also found to affect the susceptibility of the genotype. Reducing sugars in tomato fruits were positively correlated, while zinc and iron content in foliage and ascorbic acid content in fruits were negatively correlated with Heliothis infestation. Coefficient of determination revealed that 87 percent variability in borer infestation was due to four factors viz., zinc, iron, ascorbic acid and reducing sugars content.

212.4.  
3

PROGRESS IN THE SEARCH FOR CHICKPEAS THAT ARE  
RESISTANT TO *HELIOTHIS ARMIGERA* Hüb.

S.S.LATEEF  
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*Heliothis* spp. are the major pests of chickpea (*Cicer arietinum* L.) throughout most areas of the World in which they are grown, with *H.armigera* (Hüb.) predominating on this crop throughout the Old World. Using an open field screening technique, the available germplasm of more than 12,000 accessions was screened at ICRISAT Center in India and some accessions were found to have considerably less pest damage than others. Subsequent tests have confirmed these differing susceptibilities, which have been found to be the result of differences in oviposition and larval retention. Cooperative studies with the Max-Planck Institute for Biochemistry at Munich have found that the amount of acid exudate on the leaves appears to be useful as a marker in distinguishing resistant and susceptible genotypes. The ICRISAT plant breeders are now crossing genotypes in attempts to intensify the resistance and to combine the pest resistance with other useful traits including resistance to fusarium wilt.

212.4.  
4 SUSCEPTIBILITY OF DIFFERENT BROADBEAN VARIETIES TO THE  
NATURAL INFESTATION OF LIRIOMYZA CONGESTA AND BRUCHUS  
RUFIMANUS AT ZAGAZIG REGION, EGYPT

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ABSTRACT

The Present investigation was carried out under local conditions of Zagazig region, Egypt to study the susceptibility of eighteen broadbean varieties to natural infestation by *liriomyza congesta* and *Bruchus rufimanus*.

Results obtained revealed that the local variety was the most susceptible to the infestation by *L.congesta* and *B. rufimanus*, while the Black 20 was the least one, Black 20 and w varieties gave the highest resistance to infestation by broadbean weevil *B. rufimanus*.

R12.4.  
5

#### RESISTANCE TO APHIS FABAE IN VICIA FABAE CULTIVARS

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Growth rate, development time, fecundity and host selection behaviour of Aphis fabae were compared on different varieties of Vicia faba in glass-house experiments. The variety "Bolero" was selected as partially resistant, showing a strong antibiosis effect and being less colonized than susceptible varieties. These two effects, nonpreference and antibiosis, reduce the amount of infestation also in field experiments. The mechanism of resistance is still unknown. First experiments show that the rate of food uptake and the effectivity of food utilisation were reduced on the resistant variety. This correlates with smaller amounts of amino acids and carbohydrates in the phloem sap. "Bolero" also reacts with a fast hypersensitive necrosis of leaf tissue around the aphid feeding site.

#### R12.4. THE BIOLOGY OF THE TWOSPOTTED SPIDER MITE, TETRANYCHUS 6 URTICAE AS AFFECTED BY RESISTANT SOLANACEOUS PLANTS

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Two solanaceous plants, Lycopersicon hirsutum F. glabratum Humb. & Bonpl. and Solanum sarachoides Sendtner were found to be resistant to the two spotted spider mite, Tetranychus urticae Koch. Leaves of both host plants are covered with glandular hairs and mites were quickly entrapped in their exudate. Even when stripped of glandular hair exudate, leaves of these plants were found improper still for mite development. On L. hirsutum leaves stripped of exudate, 40% of T. urticae larvae developed to the deutonymphal stage, but none survived till the adult stage. On similar leaves of S. sarachoides, all mites died before reaching the deutonymphal stage.

For comparative purposes, the experimental work included also leaves of L. esculentum, c.v. Stakeless upon which 40% of the larvae reached the adult stage.

**12.5.**  
**1** EVALUATION OF ACTION THRESHOLDS FOR DEFOLIATING CATERPILLARS  
ON WINTER CABBAGE AT CENTRAL TAIWAN

CHIOU-NAN CHEN<sup>1</sup> and WEN-FENG HSIAO<sup>2</sup>

<sup>1</sup>Council for Agricultural Planning and Development, Taipei 107, ROC and

<sup>2</sup>Plant Protection Center, Taiwan 431, Republic of China

Action thresholds for defoliating caterpillars on winter crop of cabbage were evaluated at central Taiwan from November to next February during 1980-1982. Larval counts of both Plutella xylostella (DBM) and Artogeia rapae crucivora were converted to DBM equivalent units based on our previous study. Control action was taken whenever the DBM units reached 10 per 10 plants before 10-leaf stage and 20 thereafter. Based on cost-benefit analysis, we noted that in the 1980 crop two sprays were warranted when using fenvalerate, permethrin or cartap. And the net profit per 1 N.T. dollar input was 8.7, 6.7 and 3.0 N.T. dollars, respectively. While in the 1981 crop three sprays were needed and the net profit was 4 N.T. dollars for decamethrin, permethrin and prothiofos.

**R12.5.**  
**2** EFFECT OF SWEET POTATO WEEVIL INFESTATION ON SWEET POTATO  
YIELD

O.I. JOARDER and M.A. KHALEQUE

Department of Botany, Rajshahi University, Bangladesh.

Weevil infestation on two sweet potato varieties (Deshi White and AIS-272-9) were moderate in 1982 and higher in 1983. The yield was found to be negatively correlated with the number of weevils in the stem in Deshi White where no correlation was found in AIS-272-9 in 1982. But in 1983 significant negative correlations were noted in both the varieties between root yield and number of weevils in the stem. In neither varieties correlation was found between yield and number of insect in the roots or percentage of root damaged in 1982 but in 1983 the later relationship was negatively correlated in Deshi White. There is significant positive correlation between number of weevils in the roots and the percentage of root damaged in both the varieties. It appears that for AIS-272-9 no reduction in root yield is expected due to weevil infestation in root or stem but for Deshi White a significant reduction in root yield is expected. Significant differences in weevil infestation in the two years, and between two varieties were noted. A significant portion of the total variation was of genotype-year interaction nature.



**R12.5.** DAMAGE OF TWO APHID SPECIES ACYRTOSIPHON PISUM(HARRIS) AND  
**3** THERIOAPHIS TRIFOLII FORMA MACULATA (BUCKTON) ON ALFALFA IN  
KARAJ, IRAN.

GH.R.RASOULIAN,  
PLANT PROTECTION DEPARTMENT, COLLEGE OF AGRICULTURE, UNIV. OF  
TEHRAN, IRAN.

For investigating the feeding effect of two alfalfa aphids on protein and foliage weight reduction two different methods were used:

The first one was screening cage method in which young alfalfa plants were artificially infested by the certain number of aphids. The infested plants were cut after 25 days and compared for yield and protein percent. The aphids decreased the foliage yield of alfalfa 27-72 percent. Protein content decreased about 25-50 percent comparing to the check.

The second method applied directly on aphid population which was recorded once a week in the field and related to alfalfa yield. The results showed that the maximum population of A.pisum has occurred in June that decreased the foliage yield of alfalfa and protein about 44% respectively. Also the maximum population of T.trifolii resulted in August-September that decreased the foliage yield about 46% comparing to the check.

**R12.6.** PROGRESS IN THE ISOLATION OF TEMPERATURE-SENSITIVE LETHAL FACTORS FOR  
**1** GENETIC SEXING IN CERATITIS CAPITATA (WIED.).

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INTERNATIONAL ATOMIC ENERGY AGENCY, WAGRAMERSTRASSE 5, P.O. Box 100,  
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The development of a genetic sexing mechanism today is of high priority for the Sterile Insect Technique (SIT) control of the Mediterranean fruit fly, Ceratitis capitata. Methods utilised and results obtained during the attempt to develop such a mechanism, based on temperature-sensitive lethal factors, will be presented and discussed.

R12.6.  
2 EFFECT OF PUPATION ON THE QUALITY OF MEDITERRANEAN FRUIT FLY

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The effect of presence or absence of a pupation medium for mature medfly, Ceratitis capitata (Wiedemann), larvae was evaluated on the basis of pupal size and weight, adult eclosion, flight ability and survival. The paper will discuss the results obtained and the implications for the mass rearing of this insect.

R12.6.  
3 PHOTOPERIOD AS POTENTIAL CONTROL AGAINST GRAPHOLITHA FUNEB-  
RANA TR. /LEP.: TORTRICIDAE/

SÁRINGER, GY. University of Agricultural Sciences, Institute for  
Plant Protection, Keszthely, Hungary

In Hungary, we carried out in laboratory experiments involving many other species among which we choosed G. funebrana to be the subject of the present work. In these experiments trials were made to determine the effect of 1/2 - 1/2 hour periods of light exposure on decreasing the number of diapausing larvae of G. funebrana at the different stages of its scotophase. Experiments were made under the short day conditions /LD 14/10/ at 23°C. Larvae were developed on slices of green plum having a diameter of 1 - 2 cm. Approached results indicated that exposure to light /300 lux/ for a period of half an hour at the third and seventh hour of scotophase was the most effective. As a result of this treatment only 28,3 ± 7,2 % of the tested larvae remained in diapause. In the field, illumination may be fulfilled by using a parachute /like that used in military techniques/ carrying the light source.

**R12.7.**

**1**

## CODLING MOTH CONTROL IN APPLE ORCHARDS AND ON APPLES FOR EXPORT

DYCK, V.A. and A.P. GAUNCE. Agriculture Canada Research Station, Summerland, British Columbia, Canada. V0H 1Z0

A model for predicting suitable times to spray insecticides for codling moth control was tested in several orchards in the Okanagan Valley, British Columbia, Canada. One year's observations showed that the model made good predictions. A procedure whereby growers would time insecticide applications according to pheromone-trap catches and degree-day accumulations is being developed.

Field application of the insect growth regulators diflubenzuron and BAY SIR 8514, and the codling moth granulosis virus, provided moderate control under a high pest infestation level.

Treatment with the fumigant methyl bromide and a period of cold storage will provide control of the codling moth (especially the diapausing larva) in apples for export.

**R12.7.**

**2**

## THE MONITORING OF THE FLIGHT OF THE PLUM FRUIT MOTH (CYDIA FUNEBRANA) BY MEANS OF PHEROMONE TRAPS

KAREL NOVÁK

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In 1976-1983 we monitored the flight of males of the plum fruit moth, *Cydia funebrana* Tr. using pheromone traps in a fruit orchard in northeastern Bohemia, not treated chemically. The abundance of adults depends partly on weather during the summer, partly on the harvest of plums. Usually we have two generations, but in the extremely cold summer of 1980 the second generation did not occur. The second generation of adults was more abundant than the first in 1976, 1977, 1982 and 1983, whereas in 1978, 1979, 1980 and 1981 the first generation was more numerous. The infestation of fruit varied between 0.1 % (1980) and 12.5 % (1983). Pheromone traps enable a relatively accurate determination of the most suitable time of chemical treatment, but so far we do not have enough data to be able to estimate the percentage of infested fruit by the number of trapped males.

R12.7.

3

### SURVEILLANCE ON RICE PESTS IN THAILAND

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A surveillance programme of the Thai Plant Protection Service Division is presently improving recommendations for integrated pest management. Thirty provincial Plant Protection Service Units have up to 3 surveillance areas with 15 rice fields each. Weekly sampling is done along a field diagonal on 10 plant groups for harmful organisms and predators.

For example, in an irrigated surveillance area in dry season 1983 with comparable sowing times and practices, the distribution and abundance of brown planthopper (*Nilaparvata lugens*) was mainly influenced by the rice growth stage; the distribution peak coinciding with the booting stage. Field counts and light trap studies indicated that *N. lugens* was migrating into the fields at early tillering and leaving the area in the booting stage. The decrease in *N. lugens* was also due to increasing spider populations.

These first results indicated that a simplified sampling procedure used by extension technicians can give a practical interpretation of the pest situation over large rice areas.

R12.7.

4

### AERIAL APHID MONITORING TO IMPROVE PEST CONTROL TACTICS

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Aphids, the most important insect pests in Britain, are monitored continuously by a network of 23 12.2 m suction traps throughout the country and coordinated since 1964 as part of the Rothamsted Insect Survey. Insect samples are collected at Rothamsted and all aphid species are identified to a tight weekly schedule. The "Aphid Bulletin", produced weekly, gives the numbers of 33 aphid species recorded from each trap during the previous week. For some species, forecasts of the timing and size of aphid infestations have been developed which are related to economic thresholds for control. Forecasting the risk of infection of autumn-sown cereals by barley yellow dwarf virus is now possible. These forecasts are combined with information from computer mapping and other rapid quantitative computer comparisons between the current situation and the historical data-base. These comparisons are made weekly for each of 10 regions in Britain for 9 pest aphid species infesting cereals, potatoes, sugar beet, field beans, hops and apples. The forecasts and the comparisons are combined in a second weekly interpretative report, the "Aphid Commentary". The two weekly reports are mailed to over 200 representatives of crop consultants, the Ministry of Agriculture, pesticide companies and farmers. Secondary dissemination reaches many thousands of farmers. The information improves timing of insecticide application and prevents unnecessary use. Future developments will include improved interpretation and the use of radar to provide additional information on aphid movement.

R12.8.  
1

INTEGRATED CONTROL OF COCOA WEEVIL BORER  
IN THE NORTHERN DISTRICT OF PAPUA NEW GUINEA

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A study of the population dynamics of cocoa weevil borer Pantorhytes szentivanyi Marshall on cocoa under different shade regimes was carried out in the Northern District of Papua from 1969 to 1973. The studies showed that shade from tall trees and coconuts combined with the predatory ant Anoplolepis longipes (Jerdon) (Hymenoptera: Formicidae) reduced the population of the flightless cocoa weevil borer. Blocks infested with the predatory ant showed less damage than those without ants.

R12.8. INTEGRATED CONTROL OF FRUIT FLY *Anastrepha fraterculus* (WIED.) IN  
2 THE APPLE GROWING AREA OF SANTA CATARINA, BRAZIL.

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South American fruit fly *Anastrepha fraterculus* (Wied.) is considered as main pest in the apple growing area of Santa Catarina, Brazil. To determine integrated pest control measures the population dynamics, the degree of apple fruit attack, host plants and natural barriers were examined showing major invasion of fruit flies above 20°C, coinciding with fly-hatching in native and cultivated fruits, other than apple. First sprays were carried out when 0.5 to 1.0 fruit fly per day were trapped in bait-glass of the Valencian type, filled with 25% vinegar, obtaining total control. Invasion of *Anastrepha fraterculus* and recommendations for its control depended on natural barriers, such as *Pinus eliotti*, *Araucaria angustifolia* and others, reducing the amount of insecticide sprays significantly.

**R12.8.**  
**3** A rational control programme for pests of Brussels sprouts in Canterbury, New Zealand.

T.A. JACKSON and R.R. SCOTT  
Entomology Department, Lincoln College, New Zealand.

Diamondback moth (Plutella xylostella (L.)), white butterfly (Artogeia rapae (L.)), and cabbage aphid (Brevicoryne brassicae (L.)) are the major insect pests of Brussels sprouts in Canterbury, New Zealand. Their occurrence and development were monitored for four seasons and this information was related to the plant phenology. Critical growth periods were thus identified and a control programme was designed and field tested. The programme gave an equivalent yield to the traditional one while insecticide costs were halved.

**R12.8.**  
**4** A PORTABLE DATA ACQUISITION, EVALUATION AND MANAGEMENT SYSTEM AS AN APPROACH TO THE OPTIMIZATION OF MANAGEMENT STRATEGIES IN CROPPING SYSTEMS

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A portable plant stress laboratory is being developed to quickly integrate environmental conditions with the biological attributes of relevant plant and animal species in extensive agricultural ecosystems. An overview of the important features of crop production in relation to arthropod population dynamics, fertilizers, soil moisture, pesticides, weather, plant diseases and plant phenology can be obtained to offer a new approach to the management of pest populations. The approach is to develop equipment and instrumentation to collect insects over large land masses, count and classify insects automatically and record and analyze weather factors at the field site.

The objectives are first to furnish growers with immediate management information which can be used to predict short-term future events; and secondly, to gather ecological data which can be used to predict long-term future events within the economic structure and time frame dictated by crop production.

**R12.8.** THE ROLE OF ENTOMOPHAGOUS INSECTS IN REDUCING NUMBERS OF PEST  
**5** POPULATIONS IN AGRICULTURAL CROPS

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Role of local entomophagous insects may be increased by limitations for the techniques, depressing the development of beneficial and incouriging harmful insects (soil application, crop rotation, pesticide nomenclature, ways and terms of its use). Special at tention is paid to the chemical control with reference to proportions between beneficial and harmful entomofauna. Application of dimethoate, metaphos and methylmercaptophose on seedlings of sugar beet resulted in 96% mortality of Aphis fabae Scop. and polyphagous predators. In case of toxication of sugar beet roots with dimethoate outcome of aphideids in relation to total number of mummies of aphids was at 99%. Protecting the beneficial field, orchard and forest fauna, providing effective technology of mass rearing of entomophagous insects in laboratory for the releases in nature may increase the role of entomophagous insects.

**R12.9.**  
**1**

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An important role of Communications Branch of Agriculture Canada is to relay the results of research to the public. Some methods of communication regarding insect problems will be mentioned. Examples of major problems of the principal regions of Canada will be given. Insect pests of households, animals, vegetables, grains and fruits will be included.

**R12.10.**

**1** PROFESSIONAL REGISTRATION IN NORTH AMERICA

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American Registry of Professional Entomologists

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Registration of professional entomologists in North America began in 1970 when the Entomological Society of America established and chartered the American Registry of Professional Entomologists to provide certification of professional status for qualified members of the Society and perform other functions. After 14 years, the Registry has a membership of 1,935 and has evolved into an effective group providing benefits for the public, the profession, employers and clients, and for the individual entomologist. These benefits and details of the Registry are described.

**12.1.**  
**1** Modelling the Potato Plant and Defoliation by the Colorado Potato Beetle

J.S. Elkinton and D.N. Ferro, Department of Entomology, University of Massachusetts, Amherst, Massachusetts 01003 USA

**Abstract:** A simulation model of potato plant growth has been adapted for cv. 'Katahdin' potatoes grown in the Northeast United States. The model uses input data on solar radiation, air temperature and humidity to predict the photosynthate production, respiration and the hourly growth increment of each plant part. We have used this model to investigate the effects of simulated defoliations of varying intensity applied at different points in the growing season. In addition we have coupled this model with laboratory information on the temperature dependent foliage consumption rates of the different Colorado potato beetle (CPB) life stages to predict the effects of different population levels of CPB at different times of the growing season on potato growth and yield.



**S12.1.**  
**2** **Potato Crop Loss Assessment of the Colorado Potato Beetle**

**D.N. Ferro, Department of Entomology, University of Massachusetts, Amherst,  
Massachusetts 01003 USA**

**Abstract:** In 1979 and 1980, populations of Leptinotarsa decemlineata (Say) were regulated by several different insecticide control strategies generating different potato, Solanum tuberosum L. (cv. 'Superior') defoliation patterns. In 1980, populations caused no more than 10 to 15% defoliation up to 45 days postplanting (dpp), yet up to 40% defoliation occurred by dpp 55 in some treatments. The potato plant was able to partially refoliate if defoliation was terminated by dpp 55 with no reduction in total yield (31 metric tons/ha) when compared with nondefoliated treatments; however, there was a reduction in the production of no. 1 grade potatoes (16.6 vs. 20.6 tons/ha). Defoliation which occurred in the two weeks before vine kill had no effect on yield. Estimated levels of defoliation based on the number of larvae and adults multiplied by their feeding rates closely approximated observed levels of defoliation.

**S12.1.**  
**3** **Insecticide Resistance of the Colorado Potato Beetle**

**A. Forgash, Department of Entomology and Economic Zoology, Rutgers  
University, New Brunswick, New Jersey 08903 USA**

**Abstract:** In certain geographical locations, Colorado potato beetle populations have managed to become resistant to every insecticide that has been used for its control. In recent years, resistance to new compounds has developed at alarming rates and, in some areas, this has placed the future of the potato-growing industry in real jeopardy. Results are presented of laboratory studies over the past 5 years on the progress of resistance to various insecticides in beetle populations from different areas of the northeastern U.S. and on the effect of synergists on the efficacy of several types of compounds used for Colorado potato beetle control. Strategies for delaying beetle resistance are discussed.

## **S12.1.** ECOPHYSIOLOGICAL AND GENETIC ASPECTS OF GEOGRAPHIC **4** VARIATIONS OF THE COLORADO POTATO BEETLE

T. H. HSIAO

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The Colorado potato beetle, Leptinotarsa decemlineata (Say), is indigenous to Mexico and southwestern United States. As a result of its adaptation to the cultivated potato, the geographic distribution of this species has expanded rapidly in North America during the past century and in continental Europe during this century. Its adaptiveness in vast geographic regions has raised the question as to how much variations exist or have evolved among populations. Beetle populations from Mexico, North America and Europe have now been examined for variations in host plant adaptations, diapause characteristics, isozyme patterns and chromosomal karyotypes. Measurable geographic variations in all these traits were detected. Our current research focuses on cytogenetic variations among geographic populations. Karyotype analysis revealed that a pericentric inversion exists on the No. 2 chromosomes. This stable mutation can be used to distinguish between the acrocentric, metacentric, and heterozygous races. By measuring the occurrence and frequency of these races, it was possible to trace the origin and spread of the Colorado potato beetle from its native habitats.

## **S12.1.** ANTIFEEDANTS FOR THE COLORADO POTATO BEETLE **5** /OVERVIEW AND OUTLOOK/

JERMY, T. AND Á. SZENTESI

Res.Inst.Plant Prot., Budapest, Pf.102, H-1525, Hungary

Many substances of very dissimilar molecular structures may exert feeding inhibition on the CPB. Presumably not single allelochemicals but combinations of them in each plant species are responsible for the deterrent effect in the majority of non-host plants. The frequency of occurrence of relatively strong inhibitory activity seems to be confined more to smaller plant subclasses. The chemical complexity of non-preference type of plant resistance should be kept in mind when breeding CPB resistant potato varieties. Albeit physiological and genetic fitness components are influenced by inhibition of feeding, it is the behavioural level which is primarily responsible for the results. Investigations on habituation to feeding inhibitors indicate that such a process is unlikely to occur in the CPB. Agricultural practice has shown that potato plants can be protected against the CPB by antifeedants. Such substances may act also as stressors reducing the resistance of the insect to other means of control.

S12.1.

6

## Mechanisms of Resistance to Colorado Potato Beetle in Tomato

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**Abstract:** The wild tomato species, Lycopersicon hirsutum f. glabratum is highly resistant to attack by several important insect pests attacking the cultivated tomato, including Leptinotarsa decemlineata (Say), Manduca sexta (L.) and Heliothis zea (Boddie). Resistance to L. decemlineata is manifested primarily as mortality of early instar larvae and is associated with high levels of 2-tridecanone in the glandular trichomes which abound on the foliage. Removal of these trichomes, in laboratory experiments, resulted in a dramatic reduction in mortality of early instars but extensive mortality occurred in the later larval instars. Thus, factors in addition to those associated with the glandular trichomes also play a role in the resistance to L. decemlineata.

S12.1.

7

## Developmental and Feeding Rates of the Colorado Potato Beetle: Comparison Between a Deterministic and Distribution Model

J.A. Logan, R.H. Voss and D.N. Ferro, Department of Natural Resources,  
Ecology Laboratory, Colorado State University, Fort Collins, Colorado  
80523 USA

**Abstract:** Application of model descriptions for description of temperature effects on critical life history parameters has led to insightful and sometimes novel interpretations of field observations. We discuss in detail the development of a deterministic model which describes temperature mediated development and feeding rates for the Colorado potato beetle. During development of this model, it became apparent that the typical deterministic approach was inadequate, particularly for high temperature description. A new distribution model, which includes the population distribution and both temperature mediated development and mortality, was developed to account for these high temperature anomalies. Application of this new model in a full population simulation has indicated the importance of including the distribution of population parameters in simulation models. The implications of distributive phenomena are particularly pronounced for analysis of interactions across trophic levels and analysis of stage specific mortality impacts.

- S12.1.** Biological Control of Edovum puttleri Grissell (Hymenoptera: Eulophidae),  
**8** an Egg Parasite of Leptinotarsa decemlineata (Say) (Coleoptera: Chrysomelidae)

**R.F.W. Schroder, Beneficial Insect Introduction laboratory, USDA, ARS, NER, BARC, IIBIII, Building 264, BARC-East, Beltsville, Maryland 20705 USA**

**Abstract:** Edovum puttleri was successfully reared on Leptinotarsa decemlineata eggs in the laboratory and increased in sufficient numbers for innoculative releases in the spring and summer. Parasite release and evaluation studies were conducted from 1981-83. For each of the three years, 65, 76 and 50% of the egg masses collected and 49, 65 and 50% of the individual masses were parasitized. The main objective of the research is to reduce losses and increase reliability of potato, tomato and eggplant production through the integration of E. puttleri into pest management programs for L. decemlineata in the United States.

- S12.1.** RESISTANCE IN SOLANUM SPP. TO THE COLORADO POTATO BEETLE:  
**9** MECHANISMS, GENETIC RESOURCES, AND POTENTIAL

MICHAEL B. DIMOCK and WARD M. TINGEY

Department of Entomology, Cornell University, Ithaca, NY USA

Multiple insecticide resistance and related difficulties have spurred the search for alternative approaches to the Colorado potato beetle problem in the northeastern USA. Certain wild Solanum spp. bearing glandular trichomes are resistant to small arthropods which become entangled in the sticky exudate of these hairs. Recent studies have indicated that glandular trichomes are involved in the resistance of these species to the Colorado potato beetle. Current efforts are directed toward ascertaining their effects on CPB behavior and physiology, as well as the influence of wild Solanum spp. on insect population dynamics in the field and laboratory. Potato glycoalkaloids have also gained renewed interest as a potential source of CPB resistance despite toxicological constraints that once appeared insurmountable. Results of germplasm screening and potato breeding studies and the potential role of host plant resistance in CPB management will also be discussed.

**S12.1.** BEHAVIOURAL RESPONSES OF THE COLORADO BEETLE TO THE STIMULATION  
**10** BY WIND AND PLANT ODOURS.

J.H. VISSER and D. THIERY,  
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The olfactory orientation of Colorado beetles in response to plant odours is recorded by making use of a locomotion-compensator combined with a wind tunnel. A beetle is able to walk freely on top of a sphere, while its movement is compensated continuously by means of two motors rolling the sphere in the opposite direction. In response to potato plants positioned upwind, starved beetles show a true odour-conditioned positive anemotaxis. The simultaneous stimulation by wind and potato plant odour causes a behavioural response which can be considered as changes in three elements: (a) suppression of idiothetic behaviour, (b) increase of locomotory activity, and (c) prolongation of preference for upwind directions. Olfactory orientation leads to host plant finding, and as such host plant finding is affected by the different ways these elements are changed in response to the stimulation by wind and plant odour. Effects of both attraction by host plant odour, as well as masking of host plant odour by the odours of nonhost plants can be evaluated by the analysis of the expression of idiothetic behaviour, locomotory activity and preference for upwind directions in the course of time.

**S12.2.** WHITEFLY INFESTATION PATTERNS AS INFLUENCED BY COTTON,  
**1** WEATHER AND HELIOTHIS: A SPECULATIVE STUDY OF SIMULATION  
MODELS

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The whitefly Bemisia tabaci GENN. is an important pest on cotton in the Sudan Gezira. A population model that is based on the age specific and time varying life table approach has been constructed and validated for B. tabaci and the cotton variety Barac. Simulation experiments indicate that weather conditions are favourable to whitefly development at least until late fall when the early sown Barac variety opens the bolls. The host plant is a very important factor in the B. tabaci life system. A reduced photosynthesis which decreases and delays yield formation appears to have little influence on whitefly infestations at boll opening. A strong interference of Heliothis larvae with cotton fruiting structures, however, changes the growth pattern of the plant and predicts high whitefly numbers at boll opening.

## **S12.2.** **2** MONITORING BEMISIA TABACI

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Most estimates of whitefly population relate, according to the purpose of the survey, either to the adults or to the pupae, these stages being easier to count than the eggs or small larvae. - Monitoring the adult population is done by visual counts or by catches with suction traps or yellow sticky traps. The latter ones are especially effective in detecting low density populations; but interpretation of the data has to take into account the activity pattern of the whitefly. Sampling of pupae yields data on population density per leaf. The sampling design has to be adapted to the specific distribution pattern of this stage which results from the biology of the pest. Possibilities to reduce the counting effort are discussed.

## **S12.2.** **3** A TECHNIQUE FOR MONITORING BEMISIA TABACI IN COTTON IN ZIMBABWE

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The development of a technique for monitoring Bemisia tabaci in cotton in Zimbabwe is described. Cotton scouting for other pests is well established in Zimbabwe and the monitoring of whiteflies had to fit into this routine and be simple, rapid and accurate if it is to be practical.

The method comprises the following. On each of 24 plants in a field of up to 20 hectares the lower side of the two youngest leaves and one leaf in the middle were examined for adult whiteflies. Counts of up to 20 on each plant were recorded. The total for all the sample plants is then converted to a mean count per plant. The merits of the technique compared with nymphal counts and adult trapping are discussed.

This standard technique has been adopted by commercial growers in areas that are potentially susceptible. Their records combined with data from experiments allow the comparison of populations between areas and between years.

**512.2.** POPULATION DENSITIES OF BEMISIA TABACI ON COTTON, ALFALFA, AND  
**5** VEGETABLES IN IMPERIAL VALLEY, CALIFORNIA

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Bemisia tabaci (Grennadius) was monitored in Imperial Valley, California on cotton, lettuce, carrots, squash and alfalfa utilizing yellow sticky traps and leaf samples from 1983 through 1984. The influence of cotton populations of B. tabaci on lettuce and vegetables was determined. Early cotton defoliation periods were studied to determine influence on population densities on fall lettuce. Infra-red aerial photography was used as a survey tool to locate wild host plants as well as agricultural host crops, and plants infected with viruses transmitted by B. tabaci.

**512.2.** POPULATION DEVELOPMENTS OF BEMISIA TABACI (GENN.)  
**6** (HOMOPTERA ; ALEYRODIDAE) ON VARIOUS COTTON VARIETIES IN  
 CUKUROVA, TURKEY

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Population developments of Bemisia tabaci (Genn.) were studied on 22 cotton varieties showing different morphological and agronomical characters in addition to standart ones cultivated in Çukurova to determine their resistance to B. tabaci. Some varieties were much more resistant to B. tabaci than the standart ones, their seed-cotton yields were also higher. Some cultivars also showed high resistance to B. tabaci but they gave lower yields. Standart varieties cultivated in Çukurova took place in susceptible groups.

512.2.  
7

## HOST PLANT RESISTANCE TO *BEMISIA TABACI*.

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*Bemisia tabaci* has a wide host range with plants of several botanical families severely attacked and damaged by it. Adults and larvae feed by sucking from the phloem bundles of the leaves. *B. tabaci* is attracted by the colour yellow and is believed not to react to odours. The procedure of host acceptance seems to be finalized by piercing and probing the plant with its mouth parts.

In its relation to its host plant, *B. tabaci* is affected mainly by the following features: (i) The external, physical characters of the leaf surface, e.g. hairiness vs. glabrousness, sticky glandular trichomes, leaf shape (okra/super okra), and probably the microclimate as a result of foliage density. (ii) The internal, chemical characters of the leaf, e.g. pH of leaf sap, or the occurrence of secondary plant metabolites which might act as repellents or toxins.

Sources and mechanisms of resistance are investigated and evaluated and breeding programs for resistance in cassava, cotton, potato and tomato are being carried out in several laboratories.

## 512.2. EFFECT OF TEMPERATURE ON LIFE HISTORY OF ERETMOCERUS MUNDUS 10 MERCET (HYMENOPTERA, APHELINIDAE)

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Biological studies on Eretmocerus mundus, a parasitoid on Bemisia tabaci Genn., were carried out on tomatoes at two constant temperatures, 14 and 25°C. The developmental periods for egg, 1st, 2nd and 3rd larval instars, and the pupal stage at 25°C were: 3, 2, 2, 3, and 6 days, respectively, whereas at 14°C developmental periods were: 10, 6, 5, 8 and 15 days for the same stages, respectively.

Adult females lived for 9 days at 25°C and for 11 days at 14°C, whereas adult males lived up to 4.5 days at 25°C and 5.7 days at 14°C. The preoviposition period ranged from 1.6 to 2.8 days. The average number of eggs laid per one female through its life was 24 eggs (range: 8 - 41 eggs). Fertilized eggs produced females, whereas unfertilized eggs produced males. The sex - ratio (male : female) in adult parasitoids was 1:1.5 at 25°C and 1:0.7 at 14°C.

12



**S12.2.** CHEMICAL CONTROL OF BEMISIA TABACI  
**12**

NAIM SHARAF

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The sweetpotato whitefly, Bemisia tabaci Gem., vector of many plant viral diseases, remains a serious threat to the production of different economic crops in various countries unless practical control methods for the diseases or the vector are achieved.

In this paper the work done on the various aspects of using chemicals to suppress whitefly populations and, subsequently, to reduce the incidence of viral diseases transmitted by it is reviewed. Chemical control of B. tabaci is evaluated.

**S12.2.** DEVELOPMENT OF A NEW PRIMARY PEST OF COTTON IN THE SUDAN:  
**13** BEMISIA TABACI, THE WHITEFLY

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In the late seventies Bemisia tabaci rose from a secondary to the primary pest of Sudanese cotton. It supplanted the cotton bollworm, Heliothis armigera, which became secondary in importance.

The reasons for this development were investigated. Since bollworms had been controlled for many years by a mixture of DDT and dimethoate, a constant selection pressure was provided for the whiteflies which later on was supplemented by a range of organophosphates such as monocrotophos and others. Resistance of B. tabaci resulted as a consequence which was assayed for the first time in the 1981/82 season and has been monitored since that time.

DDT, at the same time, provided a strong stimulus of whitefly fertility, increasing egg production and the frequency of generation cycles. Both, an increase of R to levels excluding field control and simultaneous stimulation of fertility by DDT residues were major causes for the whitefly-problem in the Sudan. Socio-economic reasons and such of agricultural technique may also have contributed.

**S12.3.** RESPONSE OF ARTHROPOD POPULATIONS TO TRICKLE AND OVERHEAD IRRIGATION  
**1** SYSTEMS IN CUT-FLOWER CHRYSANTHEMUMS

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UF IFAS AREC, 5007-60th Street East, Bradenton, Fla., USA 34203

Experiments were conducted during 1982 and 1983 to determine the effects of production systems associated with trickle or overhead sprinkler irrigation on arthropod populations and damage to chrysanthemum (Chrysanthemum x morifolium Ramat.) 'Manatee Yellow Iceberg' when none, low levels and high levels of insecticides were used. Production systems with trickle irrigation resulted in greatly increased twospotted spider mites (Tetranychus urticae Koch) and leafminers (Liriomyza trifolii (Burgess)); damage to chrysanthemum leaves by mites and leafminers was much greater under trickle as compared to overhead sprinkler irrigation. Increased leafmining under trickle irrigation was related to increased leaf nitrogen content. There was apparently little reduction in the effectiveness of the pesticides used attributable to overhead sprinkler irrigation.

**S12.3.** WEEDS AS ALTERNATIVE HOSTS FOR LIRIOMYZA LEAFMINERS IN A HORTICULTURAL  
**2** CROP PRODUCTION AREA OF FLORIDA

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The relative abundance of weed species were determined weekly at selected sites on the Florida west coast horticultural crop production area during 1982-83. The numbers of Liriomyza larvae and emergent leafminer and leafminer parasite adults were recorded from the foliage of each weed species. Of the leafminer larvae observed, 68-89% occurred in foliage of only 4 weeds (nightshade, Solanum spp.; common beggar-tick, Bidens alba (L.); American burnweed, Erechtites hieracifolia (L.) Raf.; and groundcherry, Physalis spp.) even though as many as 33 plant species were present. L. trifolii (Burgess) was the most abundant leafminer reared from weed foliage and was especially prevalent from Solanum spp. Opius spp. were the most abundant leafminer parasites emerging from weed foliage. In laboratory experiments with L. trifolii, more eggs were deposited and larvae developed more quickly in foliage of S. nodiflorum Jacq. than in foliage of B. alba or P. pubescens L.

S12.3.  
3

THE DEVELOPMENT OF A PEST MANAGEMENT PROGRAM FOR ARTHROPOD PESTS  
ON CHRYSANTHEMUM.

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For growers of chrysanthemums as cut flowers, pot plants or bedding plants, the leafminer Liriomyza trifolii (Burgess) continues to be a serious problem. In addition, the beet armyworm, Spodoptera exigua Hubner, has increased dramatically in importance during the past two years. Of less importance but still of concern to the growers are spider mites and several species of aphids or thrips.

The pest management program for chrysanthemum, when completed, will rely heavily on the use of insecticides. However, significant strides are being made towards better use of insecticides through the development of sampling plans and through a better understanding of the pest's biology. In addition, the use of parasites for control of leafminers appears promising.

S12.3.  
4

Studies on the biology, ecology and natural enemies of  
Chrysanthemum aphid: Macrosiphoniella sanborni (Gill.)  
in Northren Iraq.

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COLLEGE OF AGRICULTURE & FORESTRY , HAMMAM AL-ALIL, IRAQ.

This aphid is reported to feed on chrysanthemum plants during the period from mid-October to late May. The species is found to have 13 generations under field conditions with an average of 17.6 days for each generation. The development of nymphal stages was completed in an average of 9.8 days. In contrast, this aphid has successfully completed 52 generations under laboratory conditions with 29 days for each generation and 6 days for the development of nymphal stages. Four predatory insects and four parasitic fungi were recorded as the main natural enemies of M. sanborni .

**S12.3.** COMPARATIVE RESPONSES OF TWO GREENHOUSE PESTS - A DIPTERAN LEAFMINER  
**5** AND A HOMOPTERAN WHITEFLY - TO VISUAL STIMULI

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Beltsville Agricultural Research Center, Beltsville, MD 20705, USA

Numerous differences were noted in the responses of the greenhouse whitefly Trialeuroides vaporariorum (Westw.) (GHWF) and the vegetable leafminer Liriomyza sativae Blanchard (VLM) to visual stimuli. GHWF was far more sensitive to subtle changes of color than VLM. In tests with lemon yellow sticky board traps, VLM preferred edges, while GHWF landed uniformly over the board. GHWF was very sensitive to board size and position, while VLM generally ignored these parameters. The results have practical implications for the use of sticky boards for control or monitoring.

**S12.3.** EFFECT OF ENVIRONMENTAL AND TANK MIX CONDITIONS ON THE ACTIVITY OF  
**6** VERTICILLIUM LECANII

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The entomopathogen Verticillium lecanii is incorporated as part of integrated pest control programs on some greenhouse crops in Europe. This research was undertaken to determine the feasibility of integrating two commercial strains of V. lecanii into some of our greenhouse control programs in the U.S. We found that it can be utilized with benomyl if V. lecanii is applied seven or more days following the fungicide application. The thermal death point of V. lecanii is above normal growing conditions but the high relative humidity for proper development is not always present in our greenhouses. Verticillium lecanii can be safely used with normal water pH and low concentrations of additives such as spreader-stickers.

### S12.3. 7

#### A NOVEL ACARICIDE-INSECTICIDE FOR USE ON ORNAMENTALS

A. ST. J. GREEN AND R. A. DYBAS

Merck Sharp & Dohme Research Laboratories, Three Bridges,  
New Jersey 08887, USA

Avermectin B<sub>1</sub> (MK-936) is a new class of broad spectrum acaricide-insecticide of microbial origin with a novel mode of action which has demonstrated exceptional potency on the major arthropod pests of ornamentals.

Extensive laboratory and field evaluations have shown that at low use rates and concentrations it will have an excellent technical fit into ornamental spray programs, particularly those directed at controlling spider mites and Liriomyza leafminers.

Its translaminar activity and within leaf residual toxicity is expected to give the product a useful bonus in the control of mites and leafminers where poor under leaf spray coverage is obtained.

It has good contact activity against additional pests which is expected to give an additional breadth of spectrum to the product.

Extensive phytotoxicity studies have shown MK-936 to be safe to a large number of ornamental species and varieties.

### S12.3. 8

#### RESPONSIBILITIES OF AN INTERNATIONAL SHIPPER TO THE INDUSTRY

JOE W. BEGLEY

Yoder Bros., Inc., P.O. Box 68, Alva, Florida 33920

The responsibilities an international grower and shipper has to the floriculture industry are defined. Emphasis is placed on varietal performance under destination environmental conditions and pathological and entomological certification. An insect-free product depends on scouting programs, weekly audits, and field assays.

**P12.1.-**  
**1** LIFE-CYCLE OF ZEUZERA COFFEA NIETNER ON GRAPE-VINE IN TAIWAN  
( LEPIDOPTERA : COSSIDAE )

CHANG, CHIA-PAO

TAICHUNG DISTRICT AGRICULTURAL IMPROVEMENT STATION.TAIWAN, R. O. C.

Coffee leopard moth (Zeuzera coffeae Nietner) is one of the most important pests of grape-vine in Taiwan. A newly hatched larva at first penetrates into young twig of grape. Later, it removes to larger limb or trunk with its larval development. The infested twig is characterized with the symptom of excreta of larva from a penetrated hole. A damaged twig becomes fragile and easy to be broken off from just beneath a hole. Furthermore , sudden leaf withering on twig ubiquitously occur. In the case of seriously damaged plant, the grape-vine entirely killed. A mature larva pupates in the larval burrow. Before emergence of adult, a pupa escapes to the outside of a burrow, and splits down pupal skin to backward. It has 2 generations annually. Periods of adults emergence fall on during April to June and August to October. Longevity of adult estimated around 2-6 days. And deposits as many as 190-1134 eggs. Egg, larval, pupal stages last 9 to 30, 73 to 205 and 19 to 36 days respectively.

**P12.1.-**  
**2** WINTER PEST PROBLEMS ON OIL-SEED RAPE IN BRITAIN

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ADAS/MAFF, Bristol, England

In Britain, several insects attack oil-seed rape crops during the autumn and winter. Most are of little or no economic significance but in recent years Psylliodes chrysocephala and Ceutorhynchus picipitarsis have caused severe damage locally and are of increasing importance.

The present status of these pests is described.

P12.1.-  
3

"HOST PLANT LOCATION BY DIPTERAN PESTS OF VEGETABLE CROPS".

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Electrophysiological recordings have been made from the antennae of female cabbage root fly (Delia radicum) and onion fly (Delia antiqua) and several volatile chemicals screened for neurophysiological activity. The results are used to determine which plant volatiles are important in aiding host plant location by these two dipteran pests. Scanning and transmission electron microscope studies of the antennae and ovipositor of D. radicum and D. antiqua were made and the morphology and distribution of the various receptors determined. (Supported by an SERC/CASE Studentship).

P12.1.-  
4

BIOLOGY AND CONTROL OF DIAPREPES ABBREVIATUS: A ROOT WEEVIL ATTACKING CITRUS AND SUGARCANE IN THE CARIBBEAN

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Diaprepes abbreviatus is a serious pest of sugarcane and citrus in the West Indies. The weevil was found in Florida in 1964 and is presently found on 15000 ha of citrus in the USA. The adults feed on new foliage, the larvae feed on roots and cause damage that leads to host decline. Eggs about 100 per mass are deposited between leaves that the female cements together. The leaves provide protection for the egg mass and usually remain together until after egg eclosion (7 days).

Because of the threat to agriculture, the U.S. Department of Agriculture (USDA) is conducting research on weevil population suppression. The methods under investigation include: foliage oil treatment to remove eggs; microbial soil treatment; IGR foliage treatment; entomophagous nematodes; chlorpyrifos soil treatment and integrated control systems.

P12.1.-

5

## STINK BUG INJURY TO PEARS

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Two species of stink bugs, Halyomorpha mista and Plautia stali, are known as the serious pest of fruit tree in Japan. The season of occurrence of injury caused by stink bugs and the factors which determined that season were investigated in pear orchards of the Japanese variety Chojuro. The injury began to occur in late May and continued by the harvest. Pear fruit was an unsuitable food from fruition time to middle May, because the high level in a phenolic compound content was kept during that period. It seemed that an aggregation pheromone produced by males participated in an intensive injury by many individuals.

P12.1.-

6

## SEPCTROBATES CERATONIAE Z.(LEP!:PYRALIDAE) IN IRAN

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Pomegranate is one of the native and important fruits of Iran.Together with Pistachio and Palm date it is one of the valuable fruit exports and its plantation is expanded specially in the margin of Dashte-Kavir. Catterpillar of pomegranate fruit moth .The damage of pomegranate fruits is recorded from long time ago.In recent years invasion of this pest became more serious so that its damage exceeds to 70% of the whole products. Geographical distribution: For many reason,this pest has very vast habitat zone,i.e.in the most tropical zone up to 30 altitude South and in Palearctic zone up to 50 latitude North is distributed.

Host plants:This insect is a polyphagus pest which attacks the fruits and seeds of various trees such as:

Life history:This insect spends winter as different larval stages or as pupa inside the infested pomegranate fruits(Either fallen fruits on the ground or remaining on the trees).This insect has 4 generation in Iran.



**P12.2.-** THE ECONOMIC IMPORTANCE OF RHOPALOSIPHUM FITCHII (SANDERSON) AND THE ROLE OF ENTOMOPAGOUS INSECTS TO CONTROL THE APHID POPULATIONS IN EARLY SEASON.  
**1**

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During the development of R. fitchii populations, the colonies grew on expanded fruit and vegetative buds.

Between the control group and the test group, significant difference in the elimination of flowers occurred during full bloom resulting from the apple colonisation of fruit buds.

However, no significant difference within the number of fruits formed at fruit set, the number that have fallen at June drop and the number yielded at harvest, occurred between the test and control groups.

During this period, biological control of R. fitchii was achieved principally by Coccinellidae and Syrphidae. The small larvae of Miridae and adults of Anthocoridae did not act as an effective agent of control on the population of R. fitchii.

**P12.2.-** SOME ASPECTS OF POPULATION DYNAMICS IN SPECIES OF THE ALEURODIDAE  
**2** FAMILY IN THE CANARY ISLANDS

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I.N.I.A. - C.R.I.D.A. - 11. Apartado, 60 LA LAGUNA CANARY ISLANDS

The two main pests of the ALEURODIDAE Family in the Canaries are: TRIALEURODES VAPORARIORUM WESTW. and ALEUROTHRIXUS FLOCCOSUS MASK, which attack greenhouse and citrus crops respectively.

The two species are susceptible to effective biological control by parasites ENCARSIA FORMOSA GAHAN (HYM. APHELINIDAE) and CALES NOACKI HOW (HYM. APHELINIDAE).

Here we are advancing preliminary results on the white flies' distribution on crops and changes in population density during plant growth, in order to determine introduction frequency of parasites, considering climatic and cultural conditions of the Islands whereby continuous production throughout the year is possible.

**P42.2.-** CORRELATIONS OF TEMPERATURE, HUMIDITY AND PHOTO-INTENSITY WITH THE  
**3** POPULATION BUILDUP OF MUSTARD APHID, LIPAPHIS ERYSIMI (KALT.)

V. K. KALRA

Assistant Professor (Entomology), Oilseeds Section, Department of Plant Breeding, Haryana Agricultural University, Hissar-125004 (India)

The data on aphid population and temperature, humidity and photo-intensity, at various levels of the crop (top, middle and bottom) were recorded from field trial using telethermometer, cobalt chloride strips and lux meter, respectively, and their correlations and partial correlations were worked out.

The temperature and the aphid population buildup were negatively correlated especially when the temperature was above the optimum i.e.  $19^{\circ}$  to  $23^{\circ}\text{C}$ . When temperature was lower than the best suited minimum range of  $2.5^{\circ}$  to  $4.5^{\circ}\text{C}$  this correlation was positive. No clearcut effect of relative humidity and photo-intensity existed on the above correlation. In some instances these factors increased the correlation even upto  $r = 0.6$ , while in other cases they had either antagonistic or no effect at all.

The correlation of aphid population and relative humidity was negative. When the relative humidity was higher than the most suitable range i.e. around 65 per cent, the correlation was negative, however, when the relative humidity was much lower than 65 per cent, significant positive correlation ( $r = 0.7$ ) existed. The temperature above  $25^{\circ}\text{C}$  had antagonistic and synergistic effect on this correlation, irrespective of the effect of temperature: but no particular trend was discernible to generalise the results.

Aphid population and photo-intensity were found to have no significant correlation.

**P42.3.-** INFLUENCE OF CULTURAL PRACTICES ON THE ATTACK OF MUSTARD  
**1** SAWFLY, ATHALIA LUGENS PROXIMA KLUG. ON INDIAN MUSTARD.

V.K. KALRA

Assistant Professor (Entomology), Deptt. of Plant Breeding, Oil Seed Section, Haryana Agril. Univ., Hissar-125004 (India)

Indian mustard, Brassica juncea Czern. & Coss. (Var. Prakash) was grown in field, in split plot design, using different cultural practices (three levels each) viz. date of sowing, nitrogen fertilization, irrigation and spacing between lines during 1976-77 and 1977-78. The data recorded on the attack of mustard sawfly, Athalia lugens proxima Klug. during 1976-77, revealed that the maximum attack by this pest (upto 24 damaged plants per plot of 4.5 m x 3.6 m size) was in irrigated late sown crop which received heavy dose of nitrogenous fertilizers (60kg/ha). The attack was comparatively more on the widely spaced crop (60 cm distance between lines) without showing much significance in other treatments. In the succeeding year also similar results were obtained, however, the irrigation requirements for increased damage by sawfly could not be confirmed when the number of plants damaged by this pest were found statistically at par in the irrigated and unirrigated crops. Therefore, it was concluded that the late sown mustard crop supplied with heavy dose of nitrogenous fertilizers will provide more convenient environment for the attack of mustard sawfly, A. lugens proxima.

**P12.3.-** THE DENSITY OF POPULATION OF BOTHYNODERES PUNCTIVENTRIS GERM. IN  
**2** YUGOSLAVIA IN THE PERIOD FROM 1961 TO 1983

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This wire worm represents the most important sugar beet pest in the north-eastern Yugoslavia. The density of population of imaga has been determined every autumn by soil checking for the purpose of long-term forecast of the occurrence of this pest. Up to now a total of 2.260 fields have been investigated, occupying the area of about 115.000 hectares. The average density was 3,5 imaga per sq m in the period from 1961 to 1970; in the next decade from 1971 to 1980 only 0,6 imaga per sq m were found. The average density of population for the period from 1981 to 1983 ranged from 4 to 8 imaga per sq m. By applying the method of precise sowing, with only 200.000 monogerm seeds per hectare, the damage of this pest increased intensively in relation to the previous periods when the density of sugar beet was higher. This paper deals with the analysis of the causes of repeated mass fertilization of beet wire worm.

**P12.4.-** DEVELOPMENT OF A GRAPE PHYLLOXERA BIOASSAY FOR ROOTSTOCK  
**1** RESISTANCE.

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A life table bioassay was developed to identify phylloxera resistant grape rootstocks obtained through a breeding program. The bioassay used 4 cm excised root pieces and involved measurement of phylloxera survivorship, fecundity and generation time. The way to interpret the assay was devised using 15 rootstocks of known resistance levels. Correlations between net reproductive rate and resistance, and adult survival and resistance yielded  $r$  values around 0.9. Generation time could not be correlated with resistance. The assay variability was tested using Ganzin 1 and Cabernet Sauvignon root pieces. Variation in assay results due to root quality and ambient temperature were considered. The assay is presently in use in a nematode resistance grape rootstock breeding program.

P12.4.-  
3

Screening for corn borer, Ostrinia furnacalis (Guenee)  
Resistance in corn.

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Sixty-four varieties of corn including inbred lines, hybrids and composites were sown for screening resistance to corn Stalk borer, Ostrinia furnacalis (Guenee) at National Corn and Sorghum Research Center, Nakorn-rajassima Province, Thailand. Artificial infestation with both sexes of corn stalk borer pupae was applied when the corn was 30 days old. Observations were made on counting number of corn plants attached with eggs, flag leaves, stems and holes after 5 days, 20 days and 70 days by rating scale from 1-5 after releasing respectively. Nineteen selected entries of corn were retested and found that the least damage caused by the corn borer are 2007, KCP 1-5-S<sub>5</sub>-2-2-1, KCP 8-2-S-1806-2-2 and KCP 8-2-S<sub>5</sub>-275-3.

P12.4.-  
4

RHOPALOSIPHUM PADI (L.) AND UNPREFERRED GRASS SPECIES

JENS WEIBULL

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The host preference and selection behaviour of a polyphagous cereal aphid species, *Rhopalosiphum padi* (L.), is being studied. Special reference is given to particular grass species which are inferior as host plants and less preferred by the aphid, compared to common barley, *Hordeum vulgare* (L.).

The results, together with information from the literature, show a correspondance between the host preference pattern and taxonomic groups of grasses. Several hypotheses are proposed to explain this relationship.

This investigation is a part of a resistance breeding project in which the study of the behavioural ecology of the aphid is emphasized.

**P42.5.-** THE POSSIBILITY TO MINIMIZE PESTICIDES USES BY USING  
1 REMOTE SENSING TECHNIQUE

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Experiments were conducted to use remote sensing technique to determine insect infestation. Thermal contours obtained by AGA thermovision camera revealed the presence of all the stages of the cotton leaf worm ,Spodoptera littoralis B. Also the adult and the nymphal stages of locust Schistocerca gregaria F.were determined . Larvae of the pink boll worms, Pectinophora gossypiella and the spiny boll worms ,Earias insulana decreased the temperature radiated from the infested bolls. The decrease in temperature increased by the increase of larvae in each boll. The variation in insect infestation by the cottony-cushion scale Icerya purchasi and the purple scale ,Lepidosaphes beckii was also recorded.

**P42.6.-** POTENTIATING INSECTICIDE MIXTURES TO CONTROL RESISTANT  
1 WHITEFLIES ON SUDANESE COTTON

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During the 1982/83 season a number of insecticides were tested for potentiating effects on resistant (R) Bemisia tabaci in the Sudan. These tests were carried out with the local strains of the Gezira with a known R-mechanism. Potentiation was sought after as an additional bonus of insecticidal efficacy to compensate for R.

A number of combinations was investigated using a practical isobole technique by which mixing ratios with optimum potentiation could be established. For a confirmation of these data, field experiments testing the candidate mixtures under Sudanese field conditions were carried out. The correlation between both sets of results demonstrated the usefulness of the toxicological isobole technique for combatting resistant field strains.

P12.6.-  
2 EFFECTS OF DIFFERENT INSECTICIDES ON ADULT  
HELIOTHIS VIRESCENS (LEPIDOPTERA: NOCTUIDAE)

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The contact and stomach toxicity of profenofos, monocrotophos, cypermethrin and chlordimeform to adult Heliothis virescens as well as the influence of these products on egg-laying and hatching rate were studied. For the contact test (initial effect and persistence) the products were applied on cotton plants with a spinning disc spray tower both at LV and ULV rates. The moths were confined to the treated leaf surfaces for 4 hours. For the feeding test the insects were fed with defined amounts of active ingredients by a newly developed technique. The adulticidal activity was assessed 3 days after treatment. The number of eggs deposited and the hatching rates were recorded during the whole period of oviposition. In their overall effectiveness and in decreasing order of activity the compounds can be ranked as follows: Profenofos > monocrotophos > cypermethrin > chlordimeform. In the contact test the ULV applications proved far superior to the LV procedure.

P12.6.-  
3 A GUIDE FOR DEALERS HANDLING AND STORING PESTICIDES

TED S. BROOK  
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A poster to remind dealers handling pesticides to protect themselves and others from pesticide exposure. Handling hazards, storage safety and handling and storage regulations are the three main topics stressed on the poster.



Section 13 Forest Entomology .....

R 13.1. *Bark Beetles: Semiochemicals/ Interactions* .....

R 13.2. *Bark Beetles: Ips typographus: Trapping* .....

R 13.3. *Bark Beetles: Ips spp.: Pheromones* .....

R 13.4. *Ambrosia Beetles* .....

R 13.5. *Beetles & Weevils (1)* .....

R 13.6. *Beetles & Weevils (2)* .....

R 13.7. *Monitoring, Risk Rating, Defensive Compounds* .....

R 13.8. *Population Dynamics: Plant Factors* .....

R 13.9. *Population Dynamics: Natural Enemies* .....

R 13.10. *Population Dynamics: Parasites, Pathogens (1)* .....

R 13.11. *Population Dynamics: Parasites, Pathogens (2)* .....

R 13.12. *Forestry: Effects of Insect Damage* .....

R 13.13. *Forest Protection* .....

R 13.14. *Local Survey* .....

R 13.15. *Miscellaneous* .....

S 13.1. *Natural Regulation of Herbivorous Insects in Forest Ecosystems* .....

S 13.2. *Environmental Disturbances and Incidence of Forest Insect Problems* .....

P 13. ....

F 13. ....



**R13.1.**  
**1** SEMIOCHEMICAL INTERACTIONS AMONG PINES, BARK BEETLES  
AND ASSOCIATED INSECTS.

RONALD F. BILLINGS

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Mechanisms of host habitat location by pine bark beetles and certain associated insects are discussed. Flight barrier traps baited with synthetic bark beetle pheromones and selected host volatiles were used to study field response preferences of the southern pine bark beetles Dendroctonus frontalis Zimm., Ips avulsus Eichh., I. grandicollis (Eichh.), I. calligraphus (Germ.) and the associated insects Monochamus spp., Thanasimus dubius (F.), and Temnochila virescens (F.). The rapid release of host volatiles from pheromone-baited traps markedly increased trap catches for certain responding insects while decreasing catches of other sympatric species. These experiments provide new insights into the role of host- and insect-produced volatiles in host selection processes and help to clarify relationships between environmental disturbances and infestations of pine bark beetles in the southern United States.

**R13.1.**  
**2** PREY SPECTRUM OF Nemosoma elongatum L. (Coleoptera: Ostomidae)  
GOVERNED BY KAIROMONE RESPONSE

HELLA HEUER & J.P. VITÉ

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Both sexes of the ostomid predator *N. elongatum* L. aggregate on bark beetle infested Norway Spruce (*Picea abies* L.) in an olfactory response to chalcogran (2-Ethyl-1,6-dioxaspiro[4,4]nonane) released by its primary prey, *Pityogenes chalcographus* L. and *Pityophthorus pityographus* RATZ as a pheromonal component. Upon landing, thigmotactic behaviour replaces the olfactory response and leads the predator to enter the galleries of subcortical insects other than *P. chalcographus* and *P. pityographus* as well in search of prey and suitable breeding places.

**R13.1.**  
**3** BEHAVIORAL CHEMICALS IN THE COMPETITIVE DISPLACEMENT OF  
BARK BEETLES AFFECTING NORWAY SPRUCE

U. KOHNLE<sup>1</sup> and D. KLIMETZEK<sup>2</sup>

<sup>1,2</sup> Forstzoologisches Institut der Universität Freiburg i.Br., BRD

In addition to the alcohols (methylbutenol, verbenol, ipsdienol, amitinol) and the spiroketal chalcogran known to achieve aggregation of bark beetles affecting Norway spruce in Central Europe (Ips spp., and Pityogenes chalcographus L., respectively), two bicyclic ketals, endo- respectively exo-brevicommin and frontalin are found to be released by and/or attractive to competitive species colonizing spruce trees in a secondary fashion. Attempts are described to manipulate pest populations such as Ips typographus L. by mass trapping while attracting secondary competitors such as Dryocoetes autographus (Ratz.) to colonize potential host material.

**R13.2.**  
**1** A PRELIMINARY ANALYSIS OF THE DYNAMICS OF WITHIN-TREE POPULATIONS  
OF IPS TYPOGRAPHUS (L.)

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Despite the importance and increased abundance of Ips typographus in European spruce forests in recent years, there has been little attempt to make a quantitative analysis of the population dynamics of this or other European conifer scolytids. Through an investigation of the possibilities of using European natural enemies in the biological control of Dendroctonus scolytids in Canada, a preliminary assessment has been made of the dynamics of within-tree populations of I. typographus in southern Bavaria. By the removal of bark from sample bolts and the analysis of the scolytid gallery systems present, partial life tables could be constructed for the immature stages. These life tables show the action of competition and natural enemies in relation to population density, bark thickness and height section in the natural regulation of within-tree populations.

## **R13.2.** ESTIMATION OF FIELD POPULATION OF IPS TYPOGRAPHUS **2** JAPONICUS USING PHEROMONE TRAP

F.KOBAYASHI<sup>1)</sup>, N.YOSHIDA<sup>2)</sup>, T.KOIZUMI<sup>2)</sup>, Y.AKITA<sup>2)</sup>, K.FUKUYAMA<sup>2)</sup>, A.YAMANE<sup>1)</sup>, T.IKEDA<sup>1)</sup>  
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2) Hokkaido Branch, FFPRI, Hitsujigaoka, Sapporo, 061-01 Japan

Ips typographus japonicus NIIJIMA is an important bark beetle of Japanese spruce, Picea jezoensis and P. glehni. Field experiments using the pheromone started in May 1982 in spruce forests in Hokkaido that had been destroyed by the typhoon in August 1981. IPSLURE (Borregaard Ind. Ltd.), the aggregation pheromone developed for Ips typographus in Europe, was used as a lure. The number of beetles caught by one trap exceeded ten thousands. The number of females trapped was far beyond the males, while the sex ratio of beetle emerged from logs was 1.0. The number of beetle caught by the pheromone trap was compared with the field population estimated from the number of entrance hole on bole. The catch ratio, which was 5% or less in 1982, greatly increased in the following year presumably because of the decrease of suitable host trees. This ratio coincided with the recapture ratio estimated by the mark-recapture method.

## **R13.2.** EFFICIENCY OF BARK BEETLE TRAPPING DEVICES **3**

V. DUBBEL

Among the various types of commercially available pheromone traps for mass trapping of bark beetle pests, the efficacy rests with defineable parameters, i.e. design, size, surface structure and collecting system. Flight barriers are generally superior to traps that induce landing, with respect to the number of beetles caught as well as with regard to a balanced sex ratio. Among flight barrier traps, those providing multiple inlets are more efficient than solid barriers, while trap colours play a minor and diversified role depending on the preference of the target species. Ultimate aim is the development of a lightweight trap that combines the advantages of a flight barrier trap as well as those of the landing trap in excluding and/or accomodating the escape of beneficial or indifferent insect species.

**R13.2.** RESPONSE IN *IPS TYPOGRAPHUS* TO LOGGING WASTE ODORS AND  
**4** SYNTHETIC PHEROMONES

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Of two separately performed experiments, the one indicated a primary attraction of *Ips typographus* to cut Norway spruce branches with green foliage of winter felled healthy, mature trees. - In the other experiment, the presence of foliated spruce branches at drainpipe traps loaded with synthetic pheromones increased significantly the beetle catches. This may indicate enhanced attraction of the pheromone through host tree odors.

**R13.3.** ON THE ROLE OF ASSOCIATED MICROORGANISMS IN THE CHEMICAL COMMUNICATION  
**1** OF THE SPRUCE BARK BEETLE, IPS TYPOGRAPHUS.

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2. Dept.Clin.Bact., Göteborg Univ., Guldhedsg.10A, 41346 Göteborg, Sweden

We have isolated, and in some cases identified, microorganisms from the hindgut of the spruce bark beetle, Ips typographus. More yeasts than bacteria were isolated. The ability of a number of the isolated yeast strains to produce oxygenated monoterpenes from water extracts of bark and phloem have been investigated. We have also studied the inter-conversion of cis-verbenol, trans-verbenol and verbenone achieved by six isolated yeasts. A Candida nitratophila strain converted 1R-cis-verbenol to trans-verbenol and 1S-cis-verbenol to verbenone. 1S-cis-verbenol is a component in the attraction pheromone of Ips typographus.

**R13.3.**  
**2** PHEROMONE COMPONENTS IN THE BARK BEETLE IPS TYPOGRAPHUS  
REFLECTING AMOUNTS AND CHIRALITY OF HOST COMPOUNDS

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2) Dept.Zool.Ecol., Lund Univ., Ecol.Bldg., Helgonav.5, S-233 62 LUND, Sweden

The spruce bark beetle, Ips typographus, uses an aggregation pheromone to attack and kill healthy spruce trees. We are currently studying several aspects of this phenomenon. Identification of volatile compounds have been made by GC-MS technique. Depending on the host tree in which the males are boring, the pheromone components are produced in different ratios. The amounts of mono-terpene hydrocarbons in the phloem and their chirality influence the blend of volatiles, produced in the beetles. The variation in amounts of pheromone components between males in different attack phases, and individual variation between males in the same attack phase, will be discussed.

**R13.3.**  
**3** BEHAVIOURAL FUNCTIONS OF PHEROMONE COMPONENTS IN THE SEXES  
OF THE BARK BEETLE, *Ips typographus*.

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The male spruce bark beetle excretes several terpene alcohols during host colonization. Field tests have shown that two of these compounds, 2-methyl-3-buten-2-ol and *cis*-verbenol together are essential for attraction, but more females than males were trapped.

In order to explain this synergism and the skewed sex ratio, experiments were performed in the field with landing and flight traps at different distances from a pheromone source, with variations in release rates over five decadic steps.

The results suggest that *cis*-verbenol functions in long range orientation, while 2-methyl-3-buten-2-ol has a close range/landing function. This could explain the synergism: both compounds have to be present in order to attract beetles from a distance and to orient the attracted beetles to the source. The long range component seems to affect sex ratio by deterring males from landing.

**R13.3.** MAINTENANCE OF SEXUALITY IN A GYNOGENETIC BARK BEETLE,

**4** *Ips acuminatus*: ROLE OF MALE DISCRIMINATION

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University of Oslo

*Ips acuminatus* is a widespread harem polygynous bark beetle, breeding in dead Scots pine. Adults overwinter under bark then disperse to fresh host material. Males initiate gallery systems and release pheromone attracting both sexes. Females court to gain entry to gallery systems. Population sex ratios range from 1.2 to more than 30 females per male. Populations consist of differing proportions of normal, sexual females and females which require sperm but produce only daughters, parthenogenetically (gynogenesis). Despite the fecundity advantage of asexual females, mixed populations persist. Models suggest male preference for sexual females can be a critical factor. Results from laboratory and field tests for male discrimination are summarized. A high incidence of pre-dispersal insemination was discovered, and its implications for *I. acuminatus* populations are discussed.

**R13.4.** AMBROSIA BEETLES - A MULTI-MILLION DOLLAR DEGRADE PROBLEM FOR  
**1** FOREST COMPANIES IN BRITISH COLUMBIA, CANADA.

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Conifer logs in coastal British Columbia are subject to ambrosia beetle attack as soon as they are felled. Recent estimates suggest current degrade losses are close to C\$65 million. New pheromone-based mass-trapping techniques have focused attention on problem areas including sawmills, dryland sorting areas, and forest settings. The case for careful woods management and rapid utilization is restated.

**R13.4.** FIELD RESPONSES OF TRYPODENDRON SPP. (COL., SCOLYTIDAE) TO  
**2** DIFFERENT CONCENTRATIONS OF LINEATIN AND  $\alpha$ -PINENE

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FIELD RESPONSES OF TRYPODENDRON LINEATUM (OLIV.) AND T. DOMESTICUM L. TO 3 DILUTIONS OF RAC. LINEATIN IN ETHANOL, COMBINED IN SEPARATE EXPERIMENTS WITH DIFFERENT CONCENTRATIONS OF RAC.  $\alpha$ -PINENE, PLUS ETHANOL, WERE STUDIED IN THE BLACK FOREST. CATCHES OF T. LINEATUM WERE SIGNIFICANTLY IMPROVED BOTH WITH LINEATIN AT  $10^{-3}$  AND  $10^{-2}$  ML/ML ADDED TO  $\alpha$ -PINENE AT  $10^{-2}$  or  $10^{-1}$  ML/ML, IN RELATION TO LOWER CONCENTRATIONS OF THE TERPENE. FOR LINEATIN AT  $10^{-1}$  ML/ML SIGNIFICANT LARGER NUMBERS OF  $\text{OO}_{++}$  RESPONDED TO  $\alpha$ -PINENE AT  $10^{-1}$  ML/ML. IN GENERAL, HIGHEST CATCHES RESULTED FROM A LINEATIN/ $\alpha$ -PINENE RATIO OF COMBINATION OF EITHER 1 OR 1/10. T. DOMESTICUM NUMBERS CAUGHT WERE ONLY SIGNIFICANTLY REDUCED WITH A HIGH  $\alpha$ -PINENE CONCENTRATION OF  $10^{-1}$  ML/ML; IN ACCORDANCE TO PREVIOUS WORK, LOW CONCENTRATIONS OF  $\alpha$ -PINENE DID NOT INHIBIT THE SPECIES' RESPONSE TO LINEATIN AND ETHANOL.

**R13.4.** USE OF LINOPRAX FOR THE CONTROL OF TRYPODENDRON LINEATUM  
**3**

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After several years of testing an optimal pheromone combination for mass attraction of T. lineatum was developed. One dispenser per season attracts high numbers of beetles in appropriate traps. This highly selective tool is suitable for monitoring the T. lineatum populations. It improves the forecasting methods and can be utilized to spot problem areas in the forest. Its main use, however, is seen in reducing populations to an economical tolerance level and thus supporting other control measures. It can be considered a valuable IPM method.

**R13.4.** PHEROMONE-BASED MANAGEMENT OF AMBROSIA BEETLES (COLEOPTERA:SCOLYTIDAE)  
**4** IN BRITISH COLUMBIA

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Commercial, pheromone-based trapping programs for ambrosia beetles, Trypodendron lineatum and Gnathotrichus sulcatus have been available in British Columbia since 1982. Lindgren funnel traps have been shown cost-effective for both species. A cumbersome, but efficient, sticky vane trap is sometimes used during the flight of T. lineatum to maximize the catch of this species. Rapid log turnover, and the use of trap log bundles improve the efficiency of the program, and may be an essential component at high beetle population levels. Development of reliable trapping impact assessment techniques have been slow, but considerable reduction of the damage to logs at some sorting areas, following the implementation of a trapping program, is strongly indicative of the efficiency of the technique. The program appears to be most efficient at low to moderate beetle populations.

**R13.5.** SIMILARITIES IN ODOR COMPOSITION OF TOMICUS PINIPERDA AND T.MINOR  
**1** AND DIFFERENCES IN THEIR BEHAVIORAL RESPONSE TO THESE ODORS

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2) Ecology Building, Lund University. Helgonav.5, 22362 Lund, Sweden

Beetles of the species Tomicus piniperda and T.minor (Coleoptera: Scolytidae) were collected in the field in different phases of gallery construction in Scots pine. A number of oxygen containing monoterpenes (e.g. trans-verbenol, 3-carene-10-ol, verbenone, myrtenol) were identified from hindguts of both sexes and both species by GC-MS. The amounts of the volatiles were highest at the time when the beetles had bored so far into the bark that they had reached contact with the tree resin. To investigate the biological role of the identified monoterpenes, we used EAG-screening, laboratory bioassay with walking beetles and field trapping. The biological activity of the insect derived volatiles were also compared with volatiles originating from the host tree.



**R13.5.** LOCATION OF BREEDING MATERIAL BY THE LARGE PINE WEEVIL, HYLOBIUS  
**2** ABIETIS (L.) (COL.: CURCULIONIDAE)

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Oviposition and larval development of Hylobius abietis (L.) occur in the phloem of freshly killed or dying conifer roots and stems in close contact with the soil. This study has confirmed that weevils walking on the ground can locate underground roots suitable for oviposition by utilizing volatiles emanating from these roots and diffusing through the soil. In order to investigate which substances are involved in this orientation, a laboratory bioassay has been developed which allows the weevils to orient as they do in the field. Substances of importance in the weevil's orientation to breeding material have been identified and combinations of these substances have also proved attractive to weevils in the field.

**R13.5.** Synergistic Effect of Ethanol in Combination with Conifer Host Volatiles as an Attractant for the Large Pine Weevil, Hylobius abietis (L.)  
**3**

David A. Tilles, Kristina Sjödin, Göran Nordlander and Hubertus H. Eidmann  
*Swedish Univ. of Agr. Sci., Uppsala, Sweden*

Field tests using pitfall traps were conducted in order to test the relative attractiveness of ethanol, other conifer volatiles, and a combination of both, to Hylobius abietis L. in Sweden. Scots pine + ethanol caught about three times as many weevils as Scots pine, alone. When used separately,  $\alpha$ -pinene, a terpene blend, and ethanol were only marginally attractive. However, a combination of ethanol with any of the terpene treatments was highly attractive. This pine weevil utilizes dead and dying roots of several conifer species as breeding substrate. Thus, it probably uses a set of volatiles characteristically found in both pine and spruce to recognize potential host species. Additionally, increased quantities of ethanol released from fermenting host material may signal that this material is in a suitable condition for weevil breeding.

**R13.5.** USE OF OVIPOSITION-SITE ATTRACTANT FOR SURVEY AND MASSTRAPPING OF THE  
**4** PINE SAWYER, THE MAJOR VECTOR OF THE PINE WOOD NEMATODE.

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In Japan pine mortality caused by the pine wood nematode has been occurring for decades, and surpression measures are aimed at the control of the pine sawyer, Monochamus alternatus Hope, the major vector of the nematode. A newly developed behavioral chemical, oviposition-site attractant offers considerable potential for use as tools in integrated pest management. Direct effects of masstrapping of the beetle on the decrease of pine mortality can not be expected, because the attracted beetles are only mature ones and have already transmitted nematodes to the pine trees. However, for the direct control of the beetles in the infested trees by burning or chemical spray can not be done completely and thoroughly, control of mature beetles may contribute to reduce population density of the beetle after years. It can be effectively used to estimate the population density of the mature beetles, and emergence occurrence can be retraced also ,because the responce to the attractant occurs about 3 weeks after the emergence.

**R13.6.** AN ANALYSIS OF THE BARK BEETLE POPULATION AND ITS  
**1** APPLIED IMPORTANCE

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A possibility of using all round methodics of the bark beetles population analysis is discussed in order to obtain data for their further number control. *Blastophagus piniperda* and *B.minor* populations in several points of their European area with different types of habitats were investigated. There were determined norm characteristics of the populations and temporal variability.

Some measures for determining the agressiveness rate of population and the expected damage rate of trees as well are suggested.

**R13.6.** SCANNING ELECTRON MICROSCOPIC STUDIES ON THE AMBROSIA FUNGI GROWING IN  
**2** THE GALLERIES OF SEVERAL AMBROSIA BEETLES (SCOLYTIDAE & PLATYPODIDAE)

TOSHIO NAKASHIMA

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Ambrosia beetles bore deeply into the wood of felled trees, logs, and stumps. The beetles cultivate symbiotic fungi or ambrosia fungi in the galleries and feed on them. However, in regard to the actual state of the beetles-fungi symbiosis, we still have little knowleges.

In the present experiment, the primary ambrosia fungi of some beetles have been isolated from mycetangia and compared with the fungi growing in the galleries. The fungi growing in each gallery where each species of the beetles has lived were also compared with each other.

The results are as follows: 1) The primary ambrosia fungi were highly specific species. 2) Monirioid type of the fungi was observed only in the galleries near larvae. 3) In overwintering period, the shape of the fungi were different from that of the active period of the beetles.

**R13.6.** THE BASIS OF PEST-HOST RELATIONSHIPS IN XYLOSANDRUS  
**3** COMPACTUS (Eich.)(COLEOPTERA : SCOLYTIDAE)

KUNNETH GOPINATH

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India.

The Xylomycetophagous scolytid, Xylosandrus compactus enjoys a circum tropical distribution and a range of hosts representing over a hundred species in about 49 families, almost all of silvicultural importance. A major pest of the important cash crop, Coffee, Coffea canephora Linn., it has defied all control measures in India. Studies on its host relationships in two areas of differing climatological profiles have revealed that population build up is governed by precipitation patterns, number of tertiary twigs available, the soil moisture holding capacity and the physiological status of the host. Also, it was seen that the diameter of the twigs governed not only the progeny number but also the sex ratio of the species.

**R13.6.** NEST AND COLONIAL STRUCTURE OF THEOBORUS THEOBROMAE HOPKINS  
4 (COLEOPTERA:SCOLYTIDAE)

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The nest structure of Theoborus theobromae Hopkins was determined. Gallery length, nest area and branch diameter was measured. Nests have digital form and they occupy one transversal plane in the host branch. Four regions were characterized: 1) entrance gallery, 2) principal chamber, 3) lateral galleries, and 4) central gallery. With the application of regression analysis it was found; the nest dimensions were independent of branch diameter and they were constant; the total area correlated with the gallery length; The dimensions of all the regions are correlated among themselves. This demonstrates the tendency of a constant form. The sex ratio was 11 females to one male. Three larval instars were founded with the use of Dyar index.

**R13.7.** A COMPREHENSIVE APPROACH TO MONITORING IN FOREST  
1 PEST MANAGEMENT SYSTEMS

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Recent research and development programs on management of major destructive forest insects in the United States have provided new information and improved techniques for monitoring pest occurrence and damage. The new technology includes improved methods of tree risk and stand/area hazard assessment as well as more rigorous methods of estimating current damage and pest population levels. Also, pest population models have been linked to stand prognosis and econometric models to provide the capability of projecting the potential effects of outbreaks on forest productivity and values. The adequacy of these planning and decision tools depends on the scope and reliability of data from monitoring. At present, this important phase of forest pest management remains fragmented. Completely integrated information systems are lacking. A more comprehensive approach, including information on multi-pest complexes, is needed. The focal point of this information system is the forest resource manager, not the pest management specialist.

**R13.7.** IMPROVED METHODS IN SURVEYING THE POPULATION DENSITY  
**2** OF FOREST PEST INSECTS IN SOUTHWEST-GERMANY

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The elimination of the causes of the "Waldsterben" (tree die-back) in Central Europe is not within the scope of forest protection. Its task is to prevent the additional defoliation by leaf- and needle-feeding larvae, the loss of weakened trees by subcortical feeding insects, and the degrading of timber by xylophagous insects. To achieve this aim a thorough survey of the population dynamics of pest insects is required in the endangered stands. There are methods at our disposal to detect changes in population density directly by the determination of abundance or indirectly by measurement of activity density. The methods for the determination of abundance could be improved by the use of new sampling techniques. To estimate the density of activity synthetic pheromones in trapping devices are used at an increasing rate. Examples are reported on both methods employed in Southwest-Germany.

**R13.7.** VULNERABILITY OF FORESTS TO SPRUCE BUDWORM DAMAGE - AN EMPIRICAL  
**3** APPROACH TO A RISK RATING SYSTEM BASED ON A LARGE SAMPLE SIZE

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Each hectare of all the productive forests of the island of Newfoundland (Canada) was given a spruce budworm (Choristoneura fumiferana (Clem.)) damage code after an outbreak of this insect. Each hectare was also rated according to stand composition, height, site class, density of host trees, and age. A multi-dimensional contingency table analysis was used to test for budworm 'preference', as judged by damage received.

**R13.7.**  
**4** DIFFERENCES IN INTER AND INTRASPECIFIC SUSCEPTIBILITY OF PINES TO THE AT-  
TACK OF EUROPEAN PINE SHOOT MOTH *RHYCIONIA BUOLIANA* SCHIFF (LEP. TORTRICIDAE)

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Differences in susceptibility of various species of indigenous and exotic pines to shoot moth attack have been investigated in arboreetums throughout France since 1972.

Differences in inter and intraspecific susceptibility have been observed between provenances in some comparative provenance trials for the species *Pinus ponderosa* LAWS., *Pinus nigra* ARNOLD and *Pinus contorta* LOUD.

Some correlations have been established between the levels of attack and the monoterpenic profiles of cortical tissues of individual trees.

**R13.7.**  
**5** IMMUNE RESPONSE OF PONDEROSA PINE TO SIMULATED DEFOLIATION: POTENTIAL  
FEEDBACK MECHANISM LIMITING NEODIPRION SAWFLY POPULATONS.

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Defense against insect herbivores may be a metabolically costly function essential in many plants. A logical evolutionary path to minimize this cost may be the development of plant defensive strategies that are engaged only when herbivores are actually present. Such an "immune response", as it is commonly called, occurs in an important forest species in the Southwestern U.S. - ponderosa pine (*Pinus ponderosa*). Defensive compounds increase significantly as a result of defoliation. This chemical change affects an important herbivore *Neodiprion fulviceps* (Hymenoptera: Diprionidae). The rate and extent of this plant response to a herbivore is discussed in relation to plant moisture stress.

**R13.8.****1****THE ROLE OF THE HOST PLANT IN THE POPULATION ECOLOGY OF  
THE BEECH SCALE**

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Within infested beech stands, the beech scale is present as a series of semi-isolated populations on individual trees, with heavily infested trees typically occurring singly or in isolated groups. Intraspecific variation in susceptibility of the host and in the colonising ability of the scale larvae have both been demonstrated and probably constitute the main natural regulating factors in population growth.

From studies of insect populations on individual trees it is clear that the largest mortality (80-90%) occurs at the first instar or crawler stage as a result of dispersal or failure to establish on the host tree. Abiotic factors such as rainwater flow down the tree trunk appear to be relatively unimportant. Establishment success has been shown to depend on physiological and physical characteristics of the bark and the presence of bark flora.

Results will be discussed in the context of the role of beech scale in the beech bark disease syndrome.

**R13.8.****2****ON THE RELEVANCE OF SECONDARY NEEDLE COMPOUNDS ON THE  
DEVELOPMENT OF PHYTOPHAGOUS INSECTS**

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The concentrations of secondary plant metabolites in conifer needles vary in dependance of season and provenance. Laboratory investigations show that secondary plant products, such as quinic acid, shikimic acid, and procyanidins, interfere with the development of the needle feeding sawflies (Diprionidae, Hymenoptera). The protein digestion of the insects is found to be a target for the mode of action of the secondary metabolites. The critical point for the insect development is the balance of nutritive and interfering needle compounds. This means that the insects are able to compensate the disturbing effects by metabolic means. Detailed investigations reveal that secondary compounds are degraded in considerable amounts during the food passage through the gut. Attempts are made to characterize physiological processes by which secondary plant products are metabolized in the insects.

**R13.8.** DEVELOPMENT OF THAUMETOPOEA PITYOCAMPA SCHIFF. (LEP., THAUMETOPOEIDAE)  
**3** IN RELATION TO FOOD CONSUMPTION.

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Field trials which were carried out in Thessaloniki area - N.Greece have shown that the food consumed by this insect affects significantly its development.

Observations on the development of young larvae which were enclosed in cloth bags on trees of an experimental site showed great affection of several biological parameters by the food that the larvae consumed. In this particular experiment food consisted of needles from five pine species, Pinus brutia, P. pinea, P. maritima, P. halepensis, and P. radiata.

It must be noted that T. pityocampa consists the most harmful needle-eating insect of the Greek pine forests.

**R13.8.** Biological Complex of Bark Beetles on Pinus sylvestris L. in the  
**4** Orleans Forest (Loiret) France.

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In Scot pine withering focuses in the Orleans forest, 3 main scolytids: Ips acuminatus (Gyllenhal), Ips sexdentatus (Boerner) and Tomicus piniperda (L.) and 187 predators, parasites and associates were identified. Three predators had an important impact: Thanasimus formicarius L. (Col.: Cleridae), Rhizophagus depressus (F.) (Col.: Rhizophagidae) and Medetera spp. (Dipt.: Dolichopodidae). The first two were especially abundant in the galleries of T. piniperda, and the third preferred I. acuminatus. The main parasites were Rhopalicus tutela (Walker), R. brevicornis Thomson (Hym.: Pteromalidae), Coeloides abdominalis Zetterstedt, C. melanostigma Strand, Dendrosoter middendorfi Ratzeburg, D. hartigii Ratzeburg and Spathius rubidus Rossi (Hym.: Braconidae). All the parasites appeared to be polyphagous. We noted a preference of C. abdominalis for T. piniperda, of S. rubidus for I. sexdentatus and of D. hartigii for I. acuminatus. R. depressus and T. formicarius immediately followed the beetles into the bark. The strongest impact of Medetera spp. and of the parasites occurred from June to August. The important action of the beneficials, mainly predators, however, was insufficient to control the high populations of bark beetles in the Scot pine withering focuses.



**R13.9.** INVESTIGATION OF REGULATORY ROLE OF MAIN PESTS' ENTOMO-  
**1** PHAGOUS INSECTS IN FORESTS OF GEORGIAN SSR

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There are analysed the twenty years experiments results of entomophagous insects influence on the series of insect species forming focus in forests of Georgia.

12 main pests species entomophagous complex is investigated too. There are more deeply traced not only the complex of entomophagous of lepidopterous insects: *Dendrolimus pini* L., *Ocneria dispar* L., *Euproctis chrysorrhoea* L., *Abraxas pantaria* L., *Parocneria terebynthi* Frr., *P. terebynthina* Stgr., but the entomophagous complex of bark beetles as well forming focus in spruce forests of the Republic. The entomophagous complex exists considerable influence on host number and the complex impoverishment too playing unfavourable role in focus during experiments.

For the pest series the condition is discussed promoting to encrease entomophagous insects role in focus and is planned the perspective introduction of parasites and predators in Georgia.

**R13.9.** A Decade of Successful Control of Pine Caterpillars  
**2** by Microbial Agents

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Dendrolimus punctatus Walker has been one of the most serious pests of the pine trees, Pinus luchuensis, P. elliattii and P. massoniana, in northern Taiwan. It develops three generations each year. During 1966-1969, a combination of three microbial agents have been used to control the pest in different plantations including a locally isolated species of Isaria, Bacillus thuringiensis (Bt), and a cytoplasmic polyhedrosis virus (CPV) isolated from D. Spectabilis Butler in Japan, after successful preliminary tests. The Isaria sp. in combination with Bt were applied for the first generation larvae (Oct. to Mar.) when it was cool and wet, the temperature and humidity were most suitable for the fungus. CPV and Bt were applied in the second (May to June) or third generation (July to Aug.) when it was favorable for the development of the virus. Since the applications, yearly observations have been made and records kept and there was no occurrence of the pest. Only until 1982, outbreaks were seen in some of the plantations and again in 1983. It is believed that the successful control was due to the microbial agents and their effectiveness had lasted for some 10-12 years.

**R13.9.** ROLE OF ENTOMOPATHOGENOUS MICROFLORA IN NUMBER REGULATION OF DENDROCTONUS MICANS KUGEL. IN GEORGIAN SSR

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In the composition of Dendroctonus's microflora are revealed 22 species of bacteria, 11 species of fungi, 2 yeasts and 2 actinomycetes. The entomopathogenous microflora of Dendroctonus is represented by chrysallophorous bacteria *Bac.thuringiensis* I and IV serotypes, unsporoving bacteria *S.marcescens*, *Aer.aerogenes*, *Ps.aeruginosa* and fungi *B.bassiana*, *B.tenella*. In natural condition from entomopathogenous microorganisms by natural infection had been died average 18-20% pest examples. The mortality of Dendroctonus had reached in larvae instar in natural condition and had peaked its maximum in the V instar and in the phase of pupa. In two vertical zonations (1000 and 1800m.a.s.l.) the pest mortality is differed by season dependence: if in May was minimal (1000a.s.l. 8,4-10,1%, 1800a.s.l. 6,9-7,4%), in July-August reached its maximum 20,8-25,6% and 20,8-24,4%, but in October it reduced everywhere.

**R13.10.** PARASITIDS AND PATHOGENS REGULATING THE LARGE PINE WEEVIL, HYLOBIUS ABIETIS L. (COL., CURCULIONIDAE), POPULATIONS ON FELLING AREAS

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In forests handled by man, many insect populations have higher densities than in natural forests. The aim of this investigation is to illustrate the regulation of such a high-density population by parasitoids and pathogens. Two parasitic wasps, and eight diseases caused by nematodes, fungi, bacteria or protozoans, on all the development stages of Hylobius abietis L. were considered. Felling areas in different parts of Sweden were studied, pre-adult stages were collected from Grohman bolts, stumps and roots. The mortality rate of eggs, young larvae and pupae were usually lower than that of the older larvae, which suffered a mortality rate between 2.4-33.8%. Predators (e.g. Diptera larvae) played an important role within stumps and superficial roots. Further down the roots, the dominating mortality factors were Bracon hylobii Ratzb. and Beauveria bassiana Bals.Vuill. Physiological status, parasitoids and diseases of H.abietis imagines from felling areas of different ages, were recorded. Among the protozoans, Nosema hylobii (Issi) seemed to be capable to act as a deleterious infection, having a relatively higher regulating efficiency on new rather than old felling areas. A braconid, Perilitus n.sp., had its greatest effect on older areas.

The biology of parasitoids and pathogens from H.abietis populations and the factors that influence their effectiveness as regulators are discussed.

**R13.10.**  
**2** BRACONIDS AS PARASITES OF FOREST INSECT PESTS

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Braconids are mostly internal parasites in insect larvae, but also ectoparasites occur among them as well as the parasitization in insect adults. With few exceptions of most primitive species they are host specialized. As regards to the forest pests, Lepidoptera and Coleoptera are the most preferred hosts of Braconids, while the parasitization in Copeognatha, Heteroptera, Hymenoptera, Raphidioptera, Planipennia, and Diptera is much less significant. They attack almost all families of Lepidoptera, but some families of Coleoptera only (e.g. Scolytidae, Curculionidae, Cerambycidae, Buprestidae, Anobiidae), whereas they are practically lacking in others as Scarabaeidae, Chrysomelidae, Elateridae, Staphylinidae etc. As only primary parasites are known among Braconids, they belong to the most important groups of parasitic Hymenoptera.

**R13.10.**  
**3** PARASITOIDS AND PATHOGENS REGULATING THE PINE MOTH, DENDROLIMUS PINI L. (LEP., LASIOCAMPIDAE), IN AREAS WITH LOW HOST POPULATION DENSITIES.

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As a rule mortality factors of insect populations are studied during outbreak situations, when high host density enhances dispersal and mass development of its enemies, but their importance is seldom considered in the periods between the outbreaks. The aim of this investigation is to record the enemies of the pine moth during low population densities in non-outbreak as compared with old outbreak areas. Trap studies with laboratory reared pine moth, in different development stages, have been conducted in relevant biotopes in Sweden and Norway during 1978-83. A total of 8 primary- and 7 hyperparasitic wasps have been found. Iseropus stercorator Fabr. and Gregopimpla bernuthii Hartig, which attack the prepupae, have been the most important regulating factors (5-80 %). They are both known from outbreak areas in Europe outside Scandinavia, where their regulating importance has been minimal. G. bernuthii together with I. stercorator have been observed from all tested biotopes except in the outbreak areas. The biology of these two species is described. Among egg parasitoids the most common species is Telenomus tetratomus (Thoms.) and among larval parasitoids Apanteles liparidis Bouche. The only pupal parasitoid found is Pimpla turionellae L. The fungus Paecilomyces farinosus has been the most important regulating factor during winter time, killing 5-20 % of the hibernating larvae. Other pathogenic fungi during summer time are Beauveria bassiana and Fusarium sp., but their infection rate is very low. The importance of the regulating factors are discussed.

**R13.11.** PECULIARITIES OF EUROPEAN SPRUCE BEETLE (DENDROCTONUS  
1 MICANS KUGEL.) NUMBER REGULATION IN GEORGIAN SSR  
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Dendrocton was discovered for the first time in 1956. From 1960 the pest number increase started caused the drying of *Picea orientalis* L. The favourable climatic conditions added the absence of natural agents regulation and comparative low resistance of eastern spruce trees all had helped to this pest to enlarge in number and to spread out in area; it appears as more injurious species for coniferous forests types.

Dendrocton manifests itself by plastic behaviour to multiply according to vertical zonality and had formed different populations. At height 1000m.a.s.l. it has a year generation, but above 2000m.a.s.l. two years need for one generation. During vegetative and overwintering period it is in all phases of ontogenesis. The pest biology is studied, is investigated as the complex of entomophagous insects as the interaction of forest ecosystem depending on stand structure and ecological condition of the growth; in number decreasing ways are worked out by recording regular role of aboriginal and introductive entomophagous insects.

**R13.11.** INVESTIGATION OF DENDROPHILOUS HORNTAIL AND SAWFLY  
2 INSECTS IN THE GEORGIAN SSR

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The experiments revealed 67 species of horntails and sawflies, but more industrial meanings have the followings: *Urocerus gigas* ssp. argonautarum sem. (Siricidae) frequently reproduced in Dendrocton damaged and drying stands; *Neodiprion sertifer* Geoffr. (Diprionidae) forming the focus in pine cultures; from this family *Coli-roa limacina* Retz., *Phyllotoma flavicollis* Guss. and *Eupareophora exarmata* Thoms. were distinguished; the last specie has firstly recorded by us in the USSR; and *Arge ochropus* L. (Argidae).

It was investigated the complex of entomophagous insects in the focus of *N. sertifer*-5 species, from which were distinguished the egg parasite-*Chrysonotomyia ruforum* Krausse, the larvae parasite-*Exenterus abruptorius* Thb., the eonymph parasite-*Dahlbominus fuscipennis* Zett. In the focus of *E. exarmata* there were 3 species of parasites, more active was *Cubocerphalus? anatorius* Grav. The parasites of *N. sertifer* had wholly decreased the populations of hosts-in the egg phase to 25-30%, in the phases of larvae and eonymph to 15-22%, but the larval parasites of *E. exarmata* to 21-28%.

**K 13.11.** THE OCCURRENCE OF SECONDARY INSECT PESTS OF COMMON PINE  
**3** IN STANDS INJURED BY THE FEEDING OF *LYMANTRIA MONACHA* L.

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In the years 1978-1983 in pine stands of Poland enormous damages caused by the feeding of *L. monacha* were observed. The weakening of trees and the deterioration of their living functions created favourable conditions for the propagation of insects from the years 1981-83 in selected sample areas in the classes I-V, showed the occurrence of 26 species of cambio-xylophages. In younger stands the most frequent species were *Pissodes notatus* F. and *Pityogenes bidentatus* Hrbst. In stands of medium and older age classes the most frequently occurring insects were *Blastophagus piniperda* L., *Trypodendron lineatum* Oliv. The feeding of *B. piniperda* and *Pissodes piniphilus* was particularly injurious since these species settled trees which might have been to regenerate the assimilation apparatus damaged by *L. monacha*.

**R 13.11.** CROSS-INFECTION OF THE VIRUS OF CYTOPLASMIC POLYHEDROSIS  
**4** IN *DENDROLIMUS PINI*

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A lab strain of the virus of cytoplasmic polyhedrosis in *Dendrolimus pini* (CPV) has been tested against a number of Lepidoptera pests giving outbreaks in forests of the USSR.

The CPV of *D. pini* has a wide range of hosts. The morphology of inclusions, virus replication and pathogenesis have been studied in 8 species of Lepidoptera. The CPV of *D. pini* has been found to be potential for biological control of forest Lepidoptera pests.

**R13.12.** THE INFLUENCE OF ATMOSPHERE POLLUTION ON PINE CULTURES AND  
1 ITS DAMAGE WITH FIR SCALS NUCULASPIS ABIETIS

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The fir scale, Nuculaspis abietis Schr. was studied on the Pinus Sosnowsky Nakai. The outbreak of this scale was observed on pine trees, especially growing in polluted environment. The influence of asphalt factory wastes on pine trees has been investigated in Georgia. The trees in smoked plots in comparison with unsmoked ones reduced the current season's canes to 48.4%, the needles were shortened by 28.5%, the weight of 100 needles was reduced by 35%, the water content in needles was reduced by 9.19%, but in two-year branches the loss totaled 2.47%. The past year needles were infested 100% with scales under the influence of waste substances. The scale population density per needle was 46 specimens on the average where as in unpolluted trees the fir scale was not detected.

**R13.12.** SOME EFFECTS OF INFESTATION BY THE BLACK PINE APHID,  
2 CINARA CRONARTII (TISSOT AND PEPPER).

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The black pine aphid is considered a serious threat to the economics of commercial pine production in Southern Africa. Two major species, Pinus patula and P. taeda are very susceptible to attack throughout their areas of distribution. Although severe infestations only occur during the dry, cool months when growth is minimal, direct damage at the feeding site results in subsequent growth deformations, shortening of main stem internodes, top and side branch die-back and even death of the tree. Injury to the cambial layer and the premature sloughing of bark provides invasion opportunities for pathogens. Dense sooty moulds growing on honeydew covered needles reduce photosynthetic efficiency. Less obvious, are the effects of the gradual drain of nutrients, water, energy and mineral resources from the tree. The effects of salivary injections are unknown but circumstantial evidence suggests an association between severe infestations of particular families of P. taeda and the formation of reaction wood and swelling at the base of the trunk. Logs from these trees distort severely in processing and are considered undesirable by saw millers. Attempts to quantify the overall effects of an infestation on loss of annual growth increment in the field are being made using systemic aphicides to prevent infestation of some plots. Reliable control of infestations at a time that favours the aphids but when the relative transpiration rate of the trees is low, has only been achieved with high volume cover sprays. Granular systemics and hypodermic injections have been less successful.

**R13.12.** A LONG-TERM EFFECT OF INSECT DEFOLIATION UPON THE GROWTH  
**3** OF PICEA ABIES.

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A plantation of Picea abies in Hokkaido was once heavily defoliated by a saw-fly, Cephalcia isschikii, in 1955-56 when the trees were 45 years old. In 1980, 5 sample trees were felled in this plantation to study the long effect of insect feeding upon the stem increment. The growth was analyzed through each of the oblique, horizontal and vertical sequences of ring-width at different heights of the stem, as proposed by Duff and Nolan (1953) and Graham (1963) of Canada. The total loss was estimated as 20 % of increment for 10 years, which was now equivalent to about 5 % loss of the total stem volume of an average tree of 70 years old.

**R13.12.** LONG-TERM EFFECTS OF DEFOLIATION BY THE DOUGLAS-FIR TUSsock MOTH,  
**4** ORGYIA PSEUDOTSUGATA

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Stands of true fir and Douglas-fir are often severely defoliated during outbreaks with resulting tree mortality, top-kill, and growth loss. Three old outbreaks were studied 35, 18, and 10 years after severe defoliation and tree damage. Over the long-term, stand growth was not as repressed as has been assumed and growth of individual trees was often enhanced. In the oldest outbreak area growth of defoliated trees has been 212 percent that of nearby non-defoliated hosts for the last 30 years. Defoliated trees in the latest outbreak area are also showing rapid recovery and greater growth during the past 5 years than nearby non-defoliated host trees. The net long-term effects of severe outbreaks are increased nutrient cycling and thinning of stands. This often results in increased growth of all species of trees in outbreak areas.



**R13.13.****1**

FOREST PROTECTION STRATEGY  
IN THE FOREST-STEPPE REGION OF THE USSR

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In the period 1975-1982 it was investigated the response of the forest to the attack of insect in the forest-steppe region of the USSR.

New results are bases for following genetical and ecological forest protection strategy:

1. Selection of forest trees for insect resistance.
2. Widening of genetical heterogeneity.

In our experiments host-parasite interactions were relative stable.

Highly plant resistance to insect pests and a wide genetical and ecological heterogeneity are key factors of forest insect population density regulation, are the bases of forest plant protection.

**R13.13.****2**

INTEGRATED PEST MANAGEMENT STRATEGIES IN  
NATIONAL PARKS OF THE UNITED STATES

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National Park areas of the United States require sound pest management practices that are effective in protecting unique national resources while minimizing risk to these same resources from both pest populations and management practices. Strategies used by the National Park Service to control problem arthropod populations, while minimizing impacts to protected resources are presented. Damage thresholds based upon sound monitoring programs are stressed.



**R13.13.** RHIZOPHAGUS GRANDIS IN INTEGRATED CONTROL SYSTEM OF  
**3** FOREST PROTECTION AGAINST DENDROCTONUS MICANS

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The introduced predator Rhizophagus grandis Gyll. of Dendroctonus micans Kugel. had been successfully acclimatized and settled out in the forest ecosystem of the Georgian SSR. The predator had itself strongly arranged in D. micans galleries and had possessed the great ability to regulate the populations of its victim. It is appeared as the important element in the forest protection integrated control system against D. micans. In spruce stands where D. micans damages had not appointed above 3%, the biological control had exclusively conducted by artificial settlement of Rh. grandis in Borjomi Gorge spruce stends. The predator has controlled the pest population in such focuses and has kept the stability below the threshold of the pest harmfulness as well.

**R13.13.** THE POTENTIAL OF CME 13406 FOR THE CONTROL OF IMPORTANT  
**4** FOREST PESTS

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CME 13406 which is a new compound of the benzoylurea group has been developed as a preventative insecticide for the control of a number of important forest pests. So far positive performance data are available for species of the genera Cheimatobia, Diprion, Hibernia, Hyponomeuta, Lymantria, Tortrix at dosages ranging from 30 to 75 g a. i./ha. The 15 SC formulation CME 13406 performed satisfactorily in High Volume and Low Volume application.

The product shows a high degree of selectivity affecting mainly lepidopterous and sawfly species and saving most of the beneficial complex. Low mammalian toxicity is an additional advantage of the compound. CME 13406 is considered to have a good potential in the control of forest pests.

R13.13.  
5

# INSECT PROBLEMS IN PINE FOREST OF KOREA

KO, J. H. (Forest Research Institute, Seoul, Korea)

The mountains of the Republic of Korea are mostly covered with forests of pine, and many of these are natural forests, especially of Pinus densiflora, but also of P. thunbergii and P. koraiensis. In recent years, serious pest problems have developed in these pine forests, the most destructive pests being Dendrolimus spectabilis, Tomicus piniperda, Thecodiplosis japonensis, Matsucoccus sp., and Dioryctria sp.

In an outbreak of the pine bark scale recently detected in coastal areas of southwestern Korea, trees weakened by the scale are killed by Cryphalus fulvus or Cenangium ferruginosum. It is in the mountains of the northeastern portion of the ROK that the cone pyralid has recently become a pest of importance in consuming the seeds of P. koraiensis.

Integrated control measures have reduced the damage of the pine caterpillar, while recovery of areas that had suffered severe pine gall midge damage is attributed to natural regulation by proctotrupoid parasites of the midge.

R13.14.  
1

# SURVEY ON THE CONE INFESTING INSECTS OF Pinus koraiensis S.et Z. IN KOREA

Park, K.T. and Ahn, S.B. (Dept. of Plant Protection, College of Agriculture Gangweon National University, Chuncheon 200, Korea)

This study was conducted to investigate the species and their life history of the cone infesting insects on Pinus koraiensis S.et Z., which the plantation has recently been increased for the production of the cone and forest itself in Korea.

The damage rate of the cone by lepidopterous pest species was found to be over 80% in average. The major species investigated as cone infesting insects of Pinus koraiensis S.et Z. in Korea are Dioryctria abietella (D.et S.), Dioryctria sylvestrella (R.), Petrova cristata (W.) and Gravitarmata margarotana (H.). All of these were known as cone infesting insects as well as pine shoot moths on Pinus spp. from abroad, however there is only one research report on D. sylvestrella on Pinus koraiensis by Saito (1941) as cone infesting insects in Korea. The life history of the major species are; 1). D. abietella- 1 generation a year, adults emerge from the early of June to the mid. of August, 2). D. sylvestrella- 2 or 3 generation a year, adults emerge from the early of May to the early of September, 3). P. cristata- 3 generation a year, adults emerge from the end of May to the mid. of September.

**R13.14.** STUDY ON THE CURCULIO GLANDIUM MERSH., WHICH IS THE MOST DIS-  
**2** TRICTIVE PEST OF ACORNS OF THE OAK TREE IN IRAN.

DR.M. ABAI

Plant Pests & Diseases Resaerch Institute, Evin, P.O.Box 3178, Tehran

There are about 13 million hectares of forest in Iran. Over 4 million hectar in the western part of the country is covered by forests. Although oak forests have been neglected in the past, present man-egment programme are designed to increase and improve the forest yie-lds of these forests.

One of the important factors to preserve these forests is to study and determined the pests and diseases of the forests trees. Initial studies have revealed a serious infestation of Curculio glan-dium Marsh., The larvae of which feeds on acorns of oak. Surveys indi-cate, that many hectars of the oak forests of south - west Iran are in-fested by this pest. The study of biology and control of Curculio glan-dium started from 1980. Attecked acorns fall-down early. Larvae leav the infested acorns feeding is finished and go to the soil and spent the larval period takes 7-9 months. The weevils should be abundant in end spring.

**R13.14.** INSECT DAMAGES IN REFORESTATIONS IN BRAZIL  
**4**

JOSÉ HENRIQUE PEDROSA-MACEDO

Rua Cambará, 50 80000 Curitiba, PR - Brazil

In the central and southern regions of Brazil there are 2.94 million ha which have been reforested with Eucalyptus (66 %), with Pinus (31.4 %) and Araucaria (2.4 %), the planting taking place since 1965. The damage caused by insects reaches new dimensions with each year. The cutting ants, Atta and Acromyrmex, are the most important insects. The control cost of leaf-cutting ants has been calculated at between US\$ 4-8 per ha annum. The control through insecticides is both constant and routine. In the regions cultivated by subtropical Pinus the predominant ants are Acromyrmex species. Lepidoptera are the main defolia-tors of Eucalyptus in the States of Minas Gerais, where damage is high, as in the others States. The Pinus patula is damaged by three Geometridae in the States of Sao Paulo and Parana. Coleoptera were registered as causing dama-ge to Cunninghamia, Pinus caribaea in the State of Minas Gerais and the Pinus taeda, P. elliotii, Eucalyptus dunii in the State of Parana. Additional in-sect species have been also observed causing damage to Brazilian reforestations.

**R13.15.** ARTIFICIAL LABORATORY BREEDING OF XYLOPHAGOUS INSECT LARVAE AND ITS  
**1** APPLICATION IN CYTOGENETIC STUDIES

BARAGAÑO<sup>1</sup>, J.R., A. NOTARIO<sup>2</sup> and M.G. DE VIEDMA<sup>1</sup>

1. Cát. Zool. y Ent., E.T.S.I. Montes, Univ. Politéc. de Madrid, Spain.

2. CRIDA 06, INIA, Madrid, Spain.

Artificial diets were used to breed xylophagous insect larvae in the Laboratory. Cytogenetic studies were then carried out on haemocytes extracted from the lymph of these larvae.

Contents: 1. Introduction.- 2. Materials and Methods. 2.1. Artificial diets. 2.2. Cytogenetic technique.- 3. Results. 3.1 Insects reared. 3.2. Caryotypes of certain species.

**R13.15.** A KEY TO THE MITES ASSOCIATED WITH IPS TYPOGRAPHUS IN SOUTH GERMANY  
**2**

JÖHN C. MOSER AND HERMANN BOGENSCHÜTZ

This key identifies 32 species of mites associated with flying Ips typographus collected from non-destructive pheromone traps in South Germany. Fifteen species were judged phoretic because they were attached to the beetles. The biologies of most of the 32 species are unknown, but three are potential parasites.

**R13.15.** THE ROLE OF THE FOREST PEST MANAGEMENT INSTITUTE IN DEVELOPING  
**3** CONTROL STRATEGIES FOR INSECT PESTS OF CANADIAN FORESTS

B.V. HELSON

Forest Pest Management Institute, Canadian Forestry Service, Sault Ste.  
Marie, Ontario, Canada P6A 5M7

Canada's forest is the most valuable natural resource held by the Canadian people. In 1981, approximately 150 million cubic meters of wood were harvested with a total value of 23 billion dollars. The export value of 13 billion dollars contributed more to Canada's balance of trade than agriculture, fisheries, mining and fuel combined. The protection of this resource from fire, disease, competing vegetation and insects is critically important. Insect pests are a major problem in Canadian forests. From 1977-1981, important pests were estimated to have caused an average annual depletion of 62.5 million cubic meters of wood.

The Forest Pest Management Institute is a national institute within the Canadian Forestry Service, Environment Canada, charged with the mandate to develop new and improved pest control strategies which will protect the forest resource while maintaining the integrity of forest and human environments. To achieve this, an integrated research program has been established to investigate potential biological control agents such as viruses, bacteria, fungi and protozoa, physiological and genetic mechanisms such as insect growth regulators, pheromones and genetic manipulation, chemical control methods, application technology as well as the environmental impact and chemical accountability of pesticides in the environment. The presentation will highlight recent research activities and achievements of this program.

**R13.15.** AUTOMATED COUNTER FOR COUNTING EGG MASSES OF THE SPRUCE BUDWORM  
**4**

DANIEL T. JENNINGS

Northeastern Forest Experiment Station, Orono, ME 04469

Reviews the design and development of an automated counter for counting egg masses of the spruce budworm, *Choristoneura fumiferana* (Clem.). The counter scans foliage samples (spruce or fir), detects egg masses based on their characteristic fluorescence, and counts the egg masses electronically.

**513.1.** THE ROLE OF ARTHROPOD PREDATORS AND PARASITOIDS IN REGULATING FOREST  
**1** INSECT HERBIVORE POPULATIONS

M.P. HASSELL

Imperial College, Silwood Park, Ascot, Berkshire, U.K.

The dynamical role of arthropod predators and parasitoids in forest ecosystems can be resolved into two components: (1) the degree of depression in the average host population level caused by the observed levels of predation or parasitism, and (2) the degree of stability conferred on the long-term interaction. Particular attention is paid to the ways that these two components are affected by the foraging strategy of the natural enemies, their sex ratios, their survival to adulthood and the relative timing of their action in relation to other host mortalities. Conclusions are illustrated from population models and, where possible, with data from natural systems and biological control programmes.

**513.1.** HERBIVORE POPULATION REGULATION AND THE STABILITY OF FOREST  
**5** ECOSYSTEMS

ALAN A. BERRYMAN, Washington State University, U.S.A.  
NILS CHR. STENSETH, University of Oslo, Norway.

A general theory of herbivore population regulation is developed by considering the influence of density-responsive feedback process that determines the potential equilibrium states, and the density-independent legislative process that determines the manifestation of particular equilibrium states. The theory is utilized, with examples, to illustrate the variety of herbivore population dynamics and to explore the effect of herbivores on the dynamic stability of forest ecosystems.

## S13.2. 1 ROLE OF DISTURBANCE IN HOST SELECTION BY BARK BEETLES

PROFESSOR DR. THOMAS L. PAYNE  
DEPARTMENT OF ENTOMOLOGY  
TEXAS A&M UNIVERSITY  
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A hypothesis is presented for the role of visual and primary olfactory stimuli in host selection by the southern pine beetle, Dendroctonus frontalis. It is hypothesized that random landing on vertical objects by the insect, coupled with non-directed orientation in response to arrestment-causing, non-specific host kairomones, increases the probability that pioneer beetles will successfully attack a suitable host tree. The lightning struck tree plays a major role in this behavior by providing a vertical profile and source of host kairomones over the vertical flight range of the beetle and a susceptible host as a focal point for initiation of an infestation.

## S13.2. 2 WIND STORMS AND FOREST INSECT PROBLEMS IN SOUTHERN PINE FORESTS.

RONALD F. BILLINGS  
Texas Forest Service, P. O. Box 310, Lufkin, TX 75901

Southern pines damaged or weakened by severe wind storms (tornadoes or hurricanes) in the southern United States become susceptible to attack by a variety of bark and wood boring insects. In east Texas, individual trees in natural stands of loblolly pine (Pinus taeda L.) were monitored at periodic intervals for insect infestation following damage by either a tornado in May, a hurricane in August, or a tornado in December, 1983. The species diversity and temporal pattern of infestation by several bark beetle species was related to extent and type of wind damage, season of occurrence and other factors.

**513.2.** EFFECT OF LIMING AND ARTIFICIAL ACID RAIN ON SOIL  
**3** INVERTEBRATES

SIGMUND HÅGVAR

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Changes in soil pH induced by lime or artificial acid "rain" in field and laboratory studies markedly influenced the abundance of several soil animal groups: Protozoa (Testacea and Ciliata), Rotifera, Nematoda, Enchytraeidae, Acari and Collembola. Different species often showed quite different reactions. Most reactions fell within two patterns: 1. Reduced abundance by acidification and/or increased abundance by liming. 2. Increased abundance by acidification and/or reduced abundance by liming. A few species were negatively affected by both acidification and liming, while no species increased in abundance in both acidified and limed soil. Certain species are especially sensitive to changes in soil pH. Laboratory studies indicate that the competition pattern between microarthropod species is affected by soil pH changes.

**513.2.**  
**4**

Dr. R. N. Coulson, Professor, Department of Entomology, Texas A&M University, College Station, Texas 77843

LIGHTNING IN THE EPIDEMIOLOGY  
OF BARK BEETLE INFESTATIONS

Epidemics of the southern pine beetle, Dendroctonus frontalis, occur as a function of the rate of initiation of new infestations (epicenters) and the subsequent growth of established infestations. Lightning-struck pines serve as the focal point for initiation of infestations. Meteorological conditions in a local area determine the distribution and abundance of lightning strikes and, hence, new epicenters. Subsequent growth of infestations is influenced by landscape characteristics, stand structure, local weather conditions affecting population growth, and the background population size. A model describing epidemiology, incorporating these components, is presented.



## **S13.2.** **5** AIR POLLUTION AND THE INCIDENCE OF FOREST INSECT PROBLEMS

FÜHRER, ERWIN

Institut für Forstentomologie und Forstschutz, Universität für  
Bodenkultur, Gregor-Mendel-Str.33, A-1180 Wien, Austria

Air polluted forest areas frequently are suffering from insect attack, thus suggesting a close relation between pollution and insect outbreak. Pollutant contamination of forest stands acts selectively to different insect species, their pattern therefore being typically shifted. Since leaf, shoot and bud mining species as well as sap sucking insects predominate free feeding ones, it is assumed that survival mostly depends upon the chance for avoiding contamination with or consumption of superficial layers of pollutant material. Stem breeding insects also are observed to be changed as to their species pattern. Phloeophagous ones, which usually attack otherwise weakened trees, are replaced by less susceptible species. Particular wood boring insects occur abundantly. - It is assumed that action of pollutants may go three ways: (1) changing tree quality, (2) affecting sensitive pests or (3) suppressing natural enemies.

## **S13.2.** **8** THE RELATIVE ROLES OF TWO COMPONENTS OF THE LOBLOLLY PINE DEFENSIVE RESPONSE TO SOUTHERN PINE BEETLE ATTACK

F. P. HAIN AND P. A. MATSON

Dept. Entomology, N.C. State Univ., Raleigh, NC 27650, USA

Loblolly pine uses several mechanisms in defense against southern pine beetle attack. We measured characteristics of the constitutive primary resin system and of the induced hypersensitive response, along with other vigor indices, on 25 year old pines growing under different levels of thinning and fertilization. Trees were then subjected to controlled attack by southern pine beetles as a bioassay of tree resistance. A combination of resin flow and hypersensitive response characteristics, which varied widely between treatments, predicted which trees were susceptible to attack.

**513.2.** HOST RESISTANCE IN LOBLOLLY PINE AND ITS RELATIONSHIP  
**9** TO SOUTHERN PINE BEETLE POPULATION DYNAMICS.

F. M. STEPHEN and T. D. PAINE

Entomology Department, University of Arkansas, Fayetteville, AR, 72701 USA

Physiological characteristics of loblolly pine, Pinus taeda L., associated with resistance to the southern pine beetle, Dendroctonus frontalis Zimm., have been measured in individual trees put under different levels of stress and in stands with different hazard ratings. Indices of overall stand resistance and individual tree vigor are associated with varying levels of within-tree D. frontalis production and mortality rates. The influence of these factors on D. frontalis infestation growth is considered.

**P13.-** THE EFFECTS OF PATCHINESS ON DENDROCTONUS FRONTALIS INFESTATION  
**1** DYNAMICS.

DR. WILLIAM D. MAWBY

North Carolina State Univ., Department of Entomology, Raleigh, NC  
27650

The infestation dynamics of Dendroctonus frontalis Zimmermann are influenced by host patchiness, seasonality and beetle population level. The effects of these influences are examined through stochastic simulation and a subsequent sensitivity analysis. Host patchiness on two levels is shown to be related to useful parameters of the dynamics such as expected intensity and interepidemic intervals. An entomological interpretation of these relations leads to suggestions for survey and control applications.

P13.-  
2

DIVERSITY AND SIMILARITY OF THE COLLEMBOLAN FAUNA OF TWO  
FOREST ESCOSYSTEMS TYPES

JESUS POZO MARTINEZ

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Collembolan fauna of a deciduous forest (Fagus silvatica L.) and an undeciduous forest (Pinus sylvestris L. and P. pinaster Aiton) from Alava (Spain) has been studied.

Stationary samplings from November 1980 to August 1981 were made. Diversity and similarity indices have been applied in order to compare both types of communities.

Results indicate a bigger number of species in the birch forest. 19 species live in both ecosystems.

The diversity studies have shown that a bigger fluctuation of the number of species in the litter of the two forests exist, being the soils more stable media. A faunistical homogeneity is observed everywhere during summer.

The dendrogram of similarities among the 20 most frequent species shows two main clusters. In the first one may be noted Protophthora cancellata Gisin, Folsomia sexoculata (Tullberg) and Paratullbergia callipygos (Börner), characteristic of the birch forest; in the second one, Friesea truncata Cassagnau, Isotoma monochaeta Kos and Isotomurus palustris (Müller), main species of the pine forest.

P13.-  
3

SIMULATION OF INTRASPECIFIC COMPETITION  
OF BARK BEETLE LARVAE

HANNU SAARENMAA<sup>1</sup> and MART C.M. DE JONG<sup>2</sup>

1 For.Res.Inst. Rovaniemi Finland 2 Wageningen The Netherlands

Presented is an attempt to make a general model for the competition of bark beetle larvae. In the model, the phloem surface is represented by a two-dimensional array where individual larvae are moving. Mortality is a sequence of two incidents: (i) A larva which has not gained the minimum mine length for emerging encounters a situation where it is surrounded by consumed phloem in all directions, and (ii) the larva does not find its way out from the exploited area before its nutritional storage is exhausted. Concluded is that the model is sensitive to changes in three parameters only: "Hearing" of larvae, minimum emerging mine length, and survival time on consumed phloem. Besides competition, the approach seems to offer possibilities to study also other under-bark processes and their interactions.

**P13.-** OBSERVATIONS ON THE SCALE INSECTS INJURIOUS  
**4** TO FORESTRY OF NORTH CHINA

TANG FANG-TEH

AGRICULTURAL UNIVERSITY OF SHANXI, CHINA

Since 1974, a country-wide survey of the scale insects pest of North China was carried out. This paper is thus intended to primarily sum up the recent knowledge on the status of this group insect pest in Palearctic region of our country.

Three parts are presented in this paper: (1) an annotated compilation of systematic catalogue included 134 species belonging to 62 genera and 8 families is given; among which 1 genus and 11 species are new to science, 13 genera and 55 species are new recorded from China; (2) report on five important groups of scale insects pest such as poplar-stem scales (Quadraspidiotus, etc.), pine bast scales (Matsucoccus), soft scales (Eulecanium, etc.), oyster-shell scales (lepidosaphes, etc.) and white mulberry scale (Pseudaulachiaspis pentagona Targ.), seriously doing damage to the forest in this area; (3) the integrated control methods comprising some ways as plant quarantine, forest management, biological and chemical control are discussed.

**P13.-** TROPHIC ANALYSIS OF HETEROPTERA HERBICOLA AND ARBORI-  
**5** COLA IN BEECH FORESTS

OLGA ŠTEPANOVIČOVÁ, ZUZANA LAPKOVÁ

Komenský-University, Bratislava, Czechoslovakia

In studying the structure of Heteroptera association of beech forests /ass. Carici pilosae-Fagetum/ 83 species have been recognized, among them 39 species occurring in wood herbal under - growth and 67 species in beech tree crowns. According to trophic specialization of the above mentioned species it has been found out that in herbicol species association, population of phytophagous species has been dominant forming as much 72.6 per cent. The association of arboricol species have reached population of the phytophagous species only 23.3 per cent and the characteristic composition of arboricol species association in the beech tree crowns has been formed by population of zoophagous and zoophytophagous species /78.7 %/.

**P13.-** FLIGHT BEHAVIOUR OF THE MINUTE PINE BARK BEETLE,  
**6** CRYPHALUS FULVUS (NIIJIMA) (COLEOPTERA:SCOLYTIDAE)

MITSUHIRO SASAKAWA and TAKAKO SASAKAWA  
Laboratory of Entomology, Faculty of Agriculture,  
Kyoto Prefectural University, Kyoto, Japan.

Experiments on the effects of light, temperature and female-boring pine log on the flight behaviour of male and female beetles were carried out under laboratory condition, using a wind tunnel (perspex, 46x46x100 cm).

The flight was influenced by temperature, and high activity was achieved between 26 and 34°C. A strong positive phototaxis was shown whether the clean air was still or moving. More number of beetles orientated significantly on the upwind centre sector of the circular flight platform in pheromone-permeated moving air than the rest, and took off from the same sector. The response flight was directed distinctly toward the logs infested longer by the virgin females.

**P13.-** EFFECTS OF STRESSED TREES ON THE POPULATION BIOLOGY  
**7** OF *Neodiprion sertifer* (HYM., DIPRIONIDAE).

STIG LARSSON and OLLE TENOW

A *N. sertifer* outbreak was mapped in southern Sweden. It was found that (i) the outbreak was preceded by summer and autumn droughts, (ii) it was limited to infertile soils, (iii) pine stands aged 20-40 yrs suffered most, (iv) it was less severe in trees benefiting from a reduced inter-tree competition, as measured from tree-ring growth, and (v) it was less severe in a fertilized stand. From these observations we suggest that the outbreak was triggered by the drought, mainly because of decreased vigor of the host trees.

To test this hypothesis we designed a field experiment where *N. sertifer* larvae were enclosed on drought-stressed, irrigated, fertilized, and irrigated + fertilized pine trees. Larval survival, length of larval period, and cocoon weight were followed throughout the feeding period for two consecutive years. Larval performance was good on non-stressed trees and did not improve on stressed trees, despite considerable differences in water status. However, these data are not, in themselves, enough to reject the tree vigor hypothesis. Possible errors in stress experiments are discussed.

P13.-  
8

PRELIMINARY SURVEY OF INSECT PESTS OF *Casuarina junghuhniana* Miq.

Dr. SIRIWAT WONGSIRI , Mr. SUPACHAI LORLOWHAKARN

Department of Biology, Faculty of Science, Chulalongkorn Univ. Thailand.

Survey to obtain insect pests of *Casuarina junghuhniana* Miq. (Casuarinaceae) were conducted at 8 provinces in the Middle and Eastern parts of Thailand. Species classification, diversity, economic important, life history and some natural enemies were studied.

Ten species of insect pests were considered as important economic pests of *C. junghuhniana*. They were in the order of Coleoptera, Lepidoptera, Homoptera, Orthoptera and Isoptera. Owing to be the serious damages species, there were 3 wood borers, *Synoxylon anale* Lesne, *Rhyzopertha* sp. (Coleoptera : Bostrichidae) and *Zeuzera coffeae* Nietn. (Lepidoptera : Cossidae); 2 bark eaters, *Aristobia approximator* Thoms. (Coleoptera : Cerambycidae) and *Cleoporus* sp. (Coleoptera : Chrysomelidae); and 1 sucking insect, *Ledra* sp. (Homoptera : Ledridae). These species have not been reported in the literature as the insect pests of *C. junghuhniana* prior to this research.

F13.-  
1 LACHNID ATTACK ON CEDRUS AND AN APPROACH TO ITS CONTROL

NOTARIO<sup>1</sup>, A., J.R. BARAGANO<sup>2</sup> and M.G. DE VIEDMA<sup>2</sup>

1. CRIDA 06, INIA, Madrid, Spain.

2. Cát. Zool. y Ent., E.T.S.I. Montes, Univ. Politéc de Madrid, Spain.

Some aspects of the behaviour of Cinara cedri Mimeur, a serious pest of ornamental cedars in Spain, are presented, as well as a method for the control of Cinara cedri and Cedrobium laportei Remaudiere by tree injection with systemic insecticides.

**F13.-**  
**2**

THE WESTERN SPRUCE BUDWORM

RUSSEL G. MITCHELL

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This 30-minute film on the western spruce budworm (Choristoneura occidentalis Freeman; Lepidoptera: Tortricidae) documents the biology, impact, and management of budworm populations in the western United States. It shows the forest types where the budworm is a problem and relates the management history that has increased outbreak frequency. It describes budworm biology and population dynamics and how forest entomologists assess populations and impact. It discusses control options and how forest managers use integrated computer models of timber growth and insect population dynamics to develop a decision support system for managing budworm populations.

**F13.-**  
**3**

BREEDING BIOLOGY OF IPS TYPOGRAPHUS L. AND PITYOGENES CHALCOGRAPHUS L.  
(FILM)

GRIES, GERHARD UND INSTITUT FÜR DEN WISSENSCHAFTLICHEN FILM, GÖTTINGEN  
Institut f. Standortlehre u. Waldhygiene, Abt. Forstzoologie der  
Univ. Göttingen

The biological propagation of the *Ips typographus* L. and the *Pityogenes chalcographus* L. in the pine forest is shown in detail in part in time compression among others the boring action of the male, the preparation of the mating place, mating, creation of the female's passage and egg-niches, egg-laying, transportation of boring dust, larvae development, pupa stage and leaving the bark. In addition places attacked by the insect and damage in the open are shown as well as the significance of the beetle in natural pine woods and commercial forests. The influence of preying opponents is shown on the *Thanasimus formicarius* L.

Section 14    **Stored Product Entomology** .....

R 14.1.    *Biology of Storage Insect Species* .....

R 14.2.    *Curative and Preventive Control Measures* .....

S 14.1.    *General Aspects of Stored Product Entomology* .....

S 14.2.    *Stored Product Acarology* .....

S 14.3.    *Nutrition, Food Attractants, and Repellents of Stored Product Insects* .....

S 14.4.    *Pheromones of Stored Product Insects: Biological, Chemical,*  
              *and Applied Aspects* .....

P 14.        .....



## R14.1. CONTEMPLATIONS ON THE ORIGIN OF INSECT SPECIES INHABITING 1 THE STORAGE ENVIRONMENT

H.Z.LEVINSON

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Storage insect species may have originated from species which have prevailed in natural or field habitats, where they are occasionally found at present. Several species are continually shifting from natural to synanthropic habitats. The former can be divided into 4 major categories: (a) unripe, overripe and partly dried fruits on trees as well as fallen and rotting fruits on the ground in southern latitudes; (b) ripening, partly dried seeds of cereal and leguminous plants in southern regions; (c) nests of bees, wasps, gregarious larvae of Lymantriidae, Thaumetopoeidae, Yponomeutidae, nests of birds, rodents and spiders; (d) egg masses, semidried carcasses of insects and plant seeds in the bark of trees. Group (a) comprises species pertaining to the genera Cadra, Ectomyelois, Ephestia, Plodia and Carpophilus, while group (b) includes Sitotroga cerealella, Sitophilus zeamais and Acanthoscelides obtectus capable of developing in ripening seeds. Group (c) comprises species of the genera Anthrenus, Attagenus, Dermestes, Megatoma and Trogoderma which may feed on carcasses or injured larvae and pupae in nests of insects and spider webs; the above and species of Alphitobius, Necrobia, Oryzaephilus, Ptinus, Tenebrio also feed on insect fragments, feathers and flesh in sparrow nests and pigeonries. Group (d) includes some dermestid species which preferably breed on eggs of Lymantria dispar. The ability of the above insects to utilize largely or partly dehydrated food of considerable host variety of plant and animal origin, possible supplementation of wanting nutrients by symbiotic microorganisms as well as sensory adaptability to different environmental conditions could have promoted the transition from natural to storage habitats.

## R14.1. HOST RESISTANCE OF PENNISETUM AMERICANUM (L.) K. SCHUM. CULTIVARS TO 2 THREE STORED-GRAIN INSECT SPECIES

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Seventy-six pearl millet cultivars were evaluated in the laboratory for resistance to Sitophilus oryzae (L.); 37 of these were selected for evaluation of resistance to Sitotroga cerealella (Oliv.) and Rhyzopertha dominica (Fab.). In 8-gram samples of millet exposed to 7 days of free-choice oviposition by S. oryzae adults (10/sample), mean numbers of progeny ranged from 10.3 to 125.7 per sample. In a no-choice test of 37 cultivars, mean survival of S. cerealella from egg to adult (20 eggs/sample) ranged from 45.8 to 89.5. In a free-choice test using R. dominica (10 adults/sample; 7 days oviposition), mean numbers of progeny ranged from 27 to 126.3. For S. oryzae and S. cerealella the more resistant cultivars had smaller seeds; no such relationship was observed for R. dominica.

Relative kernel "hardness" of selected resistant and susceptible cultivars is being determined; pearling or a diamond-pointed penetrometer indicated that kernels of more resistant cultivars are harder. Determinations are being made of the relative proportions of corneous and floury endosperm in the resistant and susceptible kernels.

R14.1.  
3

HOST SPECIFICITY IN BRUCHUS LENTIS FROHL.  
( BRUCHIDAE ; COLEOPTERA)

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Bruchus lentis Frohl. is a pest of Lens esculenta Moench. The bruchid is monophagous, univoltine and attacks the green pods of the host in the field. The emergence of adult bruchids in the harvested seeds starts in July-August and continues upto December-January. Whereas the adults emerging early fly into the field and hide themselves under some protective places to surpass the adverse cold condition, a majority of them remain confined to the store. Both males and females have immature gonads during the first few months after emergence. The testes become fully mature in the month of December but the ovaries remain undeveloped till the end of February and develop rapidly when the females are fed on the flowers of Lens esculenta. However, both the sexes need to be fed on the flowers of the host plant to initiate copulation. It is thus evident that feeding on the flowers of the host plant is essential both for the maturation of the ovaries and the onset of copulation. Such a relationship decides the host specificity of Bruchus lentis which attacks the seeds of Lens esculenta only. Such a pattern of host specificity is also seen in other species of field bruchids and perhaps in many other insect species.

R14.1.  
4

BIOLOGY OF SITOPHILUS ORYZAE-A MODEL  
FOR GENETIC CONTROL OF INSECT PESTS.

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The biology of rice weevil, Sitophilus oryzae makes its control by conventional means (Fumigation) difficult. Eggs are laid inside the grains where larvae find abundance of food and are well protected against external injury. They are also protected against insecticides, parasites and predators. Though the females can lay up to 7 eggs in one grain but at the maximum two adults emerge from a single grain. This is because of the internecine behavior of the larvae. Females distribute their eggs widely when sufficient number of grains are available. Highest number of eggs are laid during the third week of ovipository life. As they exist as isolated populations, they could well serve as models for genetic control of pest species. They are easy to rear and present no problems which are often associated with mobile insect populations.

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**R14.1.** BIOLOGY OF TRIBOLIUM FREEMANI and ITS HYBRID OF TRIBOLIUM  
**5** CASTANEUM.

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To date, extremely little information exists regarding Tribolium freemani because, for nearly a century, any individual of the insect was not captured until the recent rediscovery of it in Japan. We have found, using rediscovered population, that T. freemani was a potential stored product pest and a sibling species of T. castaneum. Life cycle was completed within a month on wheat-feed in optimal condition( 30 - 33°C and 70 - 80 RH% ). However, larvae in mass culturing failed to pupate for more than 6 months caused by crowding effect of larvae. In interspecific crosses paired with each species in castaneum - section; T. castaneum, T. madens or T. audax, the cross between T. freemani and T. castaneum could only produce  $F_1$  progeny; no fertility appeared in the hybrids. Reproductive rate, longevity and resistance to starvation will be discussed

**R14.1.** A STUDY ON HISTOLOGY AND HISTOCHEMISTRY OF SOME CERTAIN  
**6** INTERNAL ORGANS OF ADULT MAIZE WEEVIL, ETC.

JIANG YONGJIA

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So far, only a few studies are reported on histology and histochemistry of some certain organs in stored grain pests in our country or abroad. They are the basis for exploration on poisoning mechanism of insecticides. The paper aims at the introduction of how to adopt paraffin section and photomicrographic technique, which not only to provide optimum experimental condition methodically, but also to explain in more detail on histology of alimentary canal and female internal reproductive organ of adult maize weevil, etc.. At the same time, It introduces the methods of Feulgen's and Brachet's Staining Methods, showing nucleic acid in the cell of the ovarioles and midgut of adult maize weevil, etc.. The later provides the simplest and handiest method for experiment so as to learn about poisoning mechanism of insecticides preliminarily after the ovarioles of pests treated with Dimilin.

## R14.2.1 CONTROL OF STORED PRODUCT INSECT PESTS BY SOLAR HEATING

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Effective equipment for disinfecting bean, grain and flour using solar heat was developed. The side of container (rectoangular solid) apart from the top was packed with a plastic foam (2 cm thick). The top was covered with glass or transparent vinyl sheet. The layer thickness of bean, grain and flour was very important factor to obtain sufficient high temperature (over 55 °C) to kill insect pests. The thickness of 4.5 cm never reached that high temperature. The thickness of 3 cm was adequate for the purpose in all cases. The glass cover was more effective than the vinyl cover. Putting a black sheet on the surface of bean, grain and flour was remarkably effective. On the day of fine weather in summer in two hours or three the temperature at the bottom of layer reached 60 °C and over. At these condition the insects of all stages were completely killed.

## R14.2.2 Studies on Methods of Controlling *Bruchus pisorum* (L) and *Bruchus rufimanus* (Bohem) in the People's Republic of China

Prof. Tsen Chi-wu The Hunan Grain Academy  
Majiachong P.O. 410002, Changsha, Hunan, China

This article deals with an integrate measurement of prevention, controlling and elimination, which, through our countless experiments, were fully proved to be most effective against broad bean weevils and pea weevils.

The main modes of it are: (1) Field control: means to spray 50% DDVP emulsion two times at the time of its florescence and pods-bearing so that the pests harm percentages can be slowed down to  $3 \pm 0.082\%$  (of broad beans) and  $0.53 \pm 0.0053\%$  (of peas). (2) Seeds treatment: Soaking in 80 °C hot water 5-10 minutes (for broad beans) and 20-30 seconds (for peas) or fumigating with ALP so that a setting point up to 100% and a 80-90 germination percentage can be obtained. (3) Storage: by the way of "Dun-in-Dun" (i.e. a smaller rounded hollow bamboo mat storing 5 Tons of peas circled by a bigger one and in between stopping it with rice husks), a 100% setting point and a  $64.6 \pm 0.012$  germination percentage were expected and of a minimum  $\text{PH}_3$  fumigation at controlled atmosphere a 275-day without pest can be sustained.

The conclusion drawn from facts is the damage from weevils could be eliminated in several years if these measurements were adopted yearly and appropriately.

R14.2.  
3

## USE OF DELTAMETHRIN (K-OTHRIN)<sup>®</sup> FOR GRAIN PROTECTION AFTER HARVEST

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ROUSSEL UCLAF-PROCIDA Saint Marcel 13367 MARSEILLE CEDEX 11 FRANCE

The activity of deltamethrin (a.i.) is particularly high on adults of grains pests by direct spraying or by residual effect. It is synergized by Piperonyl Butoxyde. Its low thermodependency is due to a relative physiological tolerance.

Formulations of deltamethrin (EC, SC, WP, dust, ULV, aso...) called "K-Othrine Grains" are recommended. On grains in bulk in all storage conditions at 0.75 ppm a.i., synergized formulations give an optimal protection for more than 12 months. At 0.5 ppm this protection last for more than 6 months and between 0.1 and 0.3 ppm it reaches 2 to 3 months against the less sensitive species and over 12 months for the others. In empty storage cells, residual treatments on walls (12.5 mg a.i./m<sup>2</sup>), or spatial treatments by fumigation or aerosols with total diffusion (1.5 g a.i./m<sup>3</sup>) or cold fogging (less than 0.5 g a.i./1000 m<sup>3</sup>) can be used.

On grains packed, dipping spraying or impregnation of packing materials give protection for rates between 15 and 65 mg a.i./m<sup>2</sup>.

R14.2.  
4

## A REVIEW OF TRIALS WITH SYNERGISED PYRETHRUM SPRAY AS A PROTECTANT TREATMENT FOR FARM-STORED GRAIN IN AUSTRALIA

H.G. GREENING

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In a series of trials at two centres in N.S.W., 1976-82, pyrethrum plus piperonyl butoxide (PBO) spray was applied to grain on intake to farm silos at 3.0 to 0.8 mg kg<sup>-1</sup> pyrethrins plus PBO 1:10, 1:15 or 1:20. Long term efficacy as a grain protectant was demonstrated for 3 mg kg<sup>-1</sup> pyrethrins plus PBO 1:10 in wheat and barley at Condobolin and in triticales at Tamworth. In efforts to economise the treatment, 2 mg kg<sup>-1</sup> pyrethrins plus PBO 1:10 or 1:15 was less effective but 1.5 mg kg<sup>-1</sup> pyrethrins plus PBO 1:20 seemed of promise. Treatment of wheat on 3 farms subsequently, at less than 2 mg kg<sup>-1</sup> pyrethrins plus PBO 1:20 was effective on 2 farms for 11 and 12 months (at 1.3 and 1.7 mg kg<sup>-1</sup> pyrethrins). On the other farm, light sub-surface infestation by *Tribolium castaneum* occurred within 4 months (at 1.2 mg kg<sup>-1</sup> pyrethrins). At the same sites the following year, supplementary surface spraying of grain, after treatment at 0.8-1.4 mg kg<sup>-1</sup> pyrethrins plus PBO 1:20, did not prevent insect infestation within 4 months, but triticales treated at 2 mg kg<sup>-1</sup> pyrethrins plus PBO 1:20 was not infested.

**R14.2.**  
**5** GRAIN FUMIGATION WITH PHOSPHINE: LIMITED SUCCESS THROUGH  
INCREASED TEMPERATURE AND HUMIDITY (E.G. HOT SPOTS)

BENZING, LOTHAR  
DETIA FREYBERG GMBH, 6947 LAUDENBACH

Under unfavourable grain temperatures some stored product pests tend to mass into so-called nests in which temperatures of more than 30° C with a grain humidity of up to 20 % can be reached. In such cases phosphine cannot penetrate sufficiently in fumigation and insects may survive. While in healthy stored grain phosphine concentrations of up to 4 000 ppm over a longer period have been established, only a short-time peak of approx. 700 ppm is reached in these nests. Other sources of humidity in stored grain can have similar influence on fumigation results. Examples will be given.

**R14.2.**  
**6** GASTIGHT SEALING - AN ESSENTIAL PART OF PHOSPHINE  
FUMIGATION

MÜNZEL, MARTIN  
DETIA FREYBERG, 6947 LAUDENBACH

Gastightness as an important precondition for a successful fumigation cannot be taken seriously enough.

Comparisous will be made between different covering materials (i.e. paper, polyethylene tarpaulin, Detia Fumigation Tarpaulin) used for flat storage fumigations with various fumigation methods (viz. Detia Fumigation Belts, Detia Bag Blankets).

The Detia Fumigation Tarpaulin proved its extreme gastightness in various phosphine surface applications where the entire grain mass was penetrated evenly.

**R14.2.** THE FUMIGATION OF WAREHOUSES WITH MAGNESIUM  
**7** PHOSPHIDE PELLETS (DETIAPHOS)

FRIEMEL, WOLFGANG  
DETIA FREYBERG GMBH, 6947 LAUDENBACH

The degassing characteristics of magnesium phosphide pellets will be compared with those containing aluminium phosphide as active ingredient by means of a diagramme.

The gas concentrations achieved after several warehouse fumigations with Detiaphos with different dosages and varying exposure times will be reported on.

Furthermore, for several foodstuffs the remaining phosphine residues after a fumigation with Detiaphos will be shown.

**R14.2.** FURTHER STUDIES ON THE STERILIZING EFFECT OF PHOSPHINE GAS  
**8** ON THE FIG MOTH EPHESTIA CAUTELLA

Z.S.AL-HAKKAK, ALYA M.B.MURAD, AFAF F. HUSSAIN, Scientific Res. Council, Biological Res. Centre, Jadiriya, Baghdad, Iraq.

In a previous investigation, an interesting result was revealed in that treatment of 3-4 day old pupae of Ephestia cautella with sublethal doses of phosphine gas induced increasing levels of sterility in the developed adults and their progeny. The present study was intended to compare the response of each sex to this effect of phosphine gas. An effective dose of 0.03mg/l for 24hrs. at room temperature was employed for comparison. The following observations were noted :-

- 1- Phosphine treatment of pupae with such a dose slightly reduced the lifespan of both male and female moths.
- 2- Fecundity was comparable between the crosses T x N, N x T and T x T. However, they were all significantly less than that of N x N.
- 3- Mating frequency was unaffected by phosphine for all the crosses.
- 4- For the above crosses, the average percentages of hatched eggs were 48.67%, 40.27%, 32.21% and 87.54%, respectively.

The results clearly suggest that because of its application advantages, phosphine fumigation could be considered as an effective chemosterilant for this serious pest of stored-products. However, it has been realised that several points regarding this conclusion needs further explication particularly those concern the competitiveness of phosphine sterilized insects.

**R14.2.** GAMMA IRRADIATION OF EGGS AND LARVAE OF  
**10** SITOTROGA CEREALELLA (OLIV.).

M.Y.Y. AHMED

Radiobiology Dept., Nuclear Res. Centre, Atomic Energy Estab., Egypt

Effects of gamma radiation exposures of 1-55 krad on the egg stage and 1-20 krad on the larval stage were studied. The dose 8 krad prevented 1-d-old egg hatch. The reproductive ability of adults irradiated as 1-d-old eggs was considerably reduced with 4 krad.

Three-d-old egg hatch was prevented by a dose 55 krad, but no adults were emerged at 20 krad.

Newly hatched larvae were unable to develop to the adult stage at 12 krad. The emergence of adults from irradiated fully grown larvae occurred at 18 krad, but all emerged adults were malformed. Again, the reproductive ability of irradiated adults as larvae was reduced.

**S14.1.** TRADITIONAL GRAIN STORAGE FACILITIES AND STORAGE METHODS  
**1** IN SOME TROPICAL COUNTRIES

HELMUT PILTZ

BLECKEDER MOOR 20, D-2122 BLECKEDE, FRG

Cereals and legumes are an important food source for the majority of the world population. Safe grain storage methods are thus of fundamental importance to ensure food supply from one harvest to the other.

Rural populations of most tropical countries have developed storage facilities which vary according to climate, moisture content and variety of the grain, time of storage as well as prevailing nutritional habits. The storage facilities are often well adapted to the local conditions.

Changes in the conditions under which local storage facilities have been developed may cause new problems.



**S14.1.** ECOLOGICAL RELATIONS OF BRUCHIDS UNDER PREHARVEST  
**2** CONDITIONS

V. LABEYRIE

IBEAS - Casino Municipal - Parc Beaumont - 64000 Pau  
(France)

The larvae of the most damaging bruchids are specialized to attack mature seeds. The initial contamination appears in the field before harvesting. This is the case of Acanthoscelides obtectus, Callosobruchus maculatus, C. chinensis, Zabrotes subfasciatus, Caryedon serratus... In each case, the importance of the infestation is induced by the influence of the ecological conditions in the agrosystem on the physiological and ethological aspects of each species. The actual knowledge of these interactions allows to define efficient means of protection of the crops to prevent the initial infestation in the store.

**S14.1.** STORAGE AND FIELD PESTS OF THE EASTERN PROVINCE OF SAUDI ARABIA:  
**3** A SURVEY BY LIGHT AND PHEROMONE TRAPS.

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Saudi Arabia is divided into four main geographical divisions: Najd, Hijaz, Asir and the Eastern Province. Over 3 million date palm trees are grown in the Eastern Province which comprises Al-Hassa and Al-Qatif oases. Underneath date palm, citrus, vine, pomme granate, figs, vegetables and alfalfa are cultivated. Both Al-Hassa and Al-Qatif Oases are provided by an irrigation and drainage system.

Storage and field pests of the Eastern Province of Saudi Arabia have been investigated using light and pheromone traps. These pests include: Pseudophilus testaceus (Cerambycidae), Oryctes elegans (Dynastidae), the nitidulid beetles Carpophilus hemipterus, C. dimidiatus, Urophorus humeralis and Haptoncus leuteolus, Oryzaephilus surinamensis (Silvanidae), Laemophloeus sp (Cucujidae), Tribolium confusum (Tenebrionidae), Lasioderma serricorne (Anobiidae), Arenipses sabella (Pyralidae), Batrachedra amydraula (Cosmopteridae), Ephestia kuhniella, Ephestia cautella and Ephestia elutella (Phycitidae), the ants Monomorium pharoensis and Camponotus spp. the wasps Polistes spp. and cockroaches.

**14.1.** SITUATION OF STORAGE AND PROTECTION OF STORED COMMODITIES AGAINST  
**4** STORAGE PESTS ESPECIALLY AT FARMER'S LEVEL IN EGYPT

FARIS EL-LAKWAH

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Investigations carried out during May and June 1983 showed that the important insect species, which are found damaging the stored products in the rural environments in Egypt are : *Sitophilus* spp., *Rhizopertha dominica* (L.), *Sitotroga cerealella* (Oliv.), *Ephestia kühniella* (Zell.), *Tribolium* spp., *Trogoderma granarium* (Everts.), *Bruchus rufimanus* (Boh.), and *Bruchidius incarnatus* (Schm.). It was also found that rodents (rats and mice) are at present the more significant pests, which are causing serious damage to the various foodstuffs stored at farmer's level. The storage period of the main stored products is different, ranging from 3 to 12 months. The storage methods used by farmers, state and co-operative stores were described and the infestation of commodities with stored products pests was recorded. The annual losses caused by rodents to the stored foodstuffs are 4 - 10 % approximately in weight, and the damage to bags and sacks is 10 - 26 % approximately.

**14.1.** PACKAGING MATERIALS AND SURFACE AS PROTECTIVE BARRIERS FOR FOODSTUFFS  
**5** AGAINST STORAGE INSECT SPECIES

Giorgio Domenichini

Direttore Istituto di Entomologia - Facoltà di Agraria - Università Cattolica del Sacro Cuore - Via Emilia Parmense, 84 - 29100 PIACENZA (Italia)

Structures used by insects to get into modern foodstuffs containers (plastic mini-silos, synthetic sacks, plywood containers, etc.) or to pierce food packagings were investigated with the S.E.M.

The study provides useful information for the choice of materials suitable for protecting foods from insect attacks.

S14.2.  
1

## STRATEGIES IN MANAGEMENT OF ACARID MITES

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A review of acarid management and current research findings is reported. Sorptive coatings eliminated Tyrophagus putrescentiae when this species was exposed to surface treated cardboard. The materials most effective were synthetic silicas. Tricalcium phosphate, talc, Bentonite clay and starch formulations were also tested. The effectiveness of the silica gel formulations appeared to be related to particle size, the finer grind being more effective in control. Citral, incorporated in a silica gel and tested as a protectant, was an effective repellent. Food additives, such as mold inhibitors, antioxidants, emulsifiers, water binders, flavoring agents and certain organic acids were tested in diets as repellents and feeding deterrents.

S14.2.  
2

## ATTRACTIVENESS OF SELECTED FOODS, FUNGI, AND ORGANIC COMPOUNDS FOR ACARID MITES

JAN BOCZEK <sup>1</sup>/<sub>1</sub>, ROBERT DAVIS <sup>2</sup>/<sub>2</sub>, AND DANUTA PANKIEWICZ-NOWICKA <sup>3</sup>/<sub>3</sub> <sup>1</sup>/<sub>3</sub> Warsaw Agric. Univ., Poland, <sup>2</sup>/<sub>2</sub> USDA-ARS, Savannah, GA, U.S.A.

Several stored-food products, fungi, wheat germ fractions and numerous chemical food components (amino acids, fatty acids, triglycerides, monosaccharids, alcohols and vitamins) were tested for their attractiveness for Carpoglyphus lactis (L.), Tyrophagus putrescentiae (Schrank) and Acarus siro L. Results of these studies will be presented and discussed.

## 514.2. PATTERNS OF GEOGRAPHICAL DISTRIBUTION OF STORED PRODUCT MITES

3

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Distributional patterns of several species and ecological species groups of stored product mites were analyzed to estimate their rate of increase in historical time, consistency of association with one another, evolutionary significance and potential for future expansion. The number of well-recognized stored-product species has increased from a handful before 1900 to 244 in 1961 and 324 in 1976. Although increased shipments of stored grain and other foods amongst various countries by modern transportation is helping the spread of mites, their distribution is still limited mainly by moisture content, region temperature and the nutritional quality of food substrates available in a region. Invasion of food by more acarine species is predicted because of the changes in dietary pattern of the human population and changing storage practices.

## 514.2. ANTIGENIC AND ALLERGENIC PROPERTIES OF THE STORAGE MITE, TYROPHAGUS PUTRESCENTIAE AND ITS CROSS-REACTIVITY WITH THE HOUSE DUST MITE.

4

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The antigenicity and allergenicity of the storage mite, Tyrophagus putrescentiae (TP) was characterized and its cross-reactivity with the house dust mite, Dermatophagoides farinae (DF) determined by crossed radio-immunoelectrophoresis and skin testing. TP bodies and TP feces extract exhibited 20 and 18 antigens, respectively. Using serum from skin test positive patients, autoradiograms demonstrated TP bodies contained 2 allergens and TP feces contained 6 allergens. TP feces and TP bodies shared 10 antigenic determinants. Two antigens common to TP feces and bodies were also shared antigens.

DF bodies exhibited 32 antigens and at least 8 allergens and DF feces exhibited 20 antigens and 6 allergens. Two antigenic and allergenic determinants were shared by DF bodies and TP bodies and two were also shared by DF feces and TP feces. TP feces and DF bodies shared 2 antigenic and allergenic determinants. Skin tests showed that 48% of patients sensitive to DF were also sensitive to TP. Twenty-six percent of patients skin test sensitive to TP were negative to DF. By RAST inhibition, TP inhibited DF binding by only 25%.

The results clearly show that TP is allergenic and has some cross-activity with the house dust mite, DF.

S14.2.  
5

## STORED PRODUCT MITES IN BRAZIL

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Brazil's largest grain producing area is located in its subtropical area and, usually, sun drying is sufficient. Not much of it is stored over a long period (mostly one year) as to allow mite development. Subproducts, like wheat bran, cotton seed meal and soybean meal have occasionally been found infested by acarids when stored in humid building or in very humid an warm regions as along the Northeastern sea cost. Heavy infestations were observed, for the first time, in 1982/83, in Southern Brazil, during an exceptionally rainy year, in soybean and tobacco. Food does not remain long enough on supermarket shelves. Cheese and meat products have occasionally been found infested at retailer level.

Primary species so far identified include: *Tyrophagus putrescentiae* (Schrank), *Aleuroglyphus ovatus* (Troupeau), *Lardoglyphus konoi* (Sasa & Asanuma), *Caloglyphus berlesei* (Michael), *Suidasia nesbitti* Hughes, *S. pontifica* (Oudemans), *Lepidoglyphus destructor* (Schrank), *Blomia tropicalis* Bronswijck, Cock & Oshima, *Gohieria fusca* (Oudemans), *Chortoglyphus arcuatus* (Troupeau) and *Carpoglyphus lactis* L..

S14.2.  
6

## STORED PRODUCTS ACAROLOGY IN SCOTLAND

I G JEFFREY

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Mite populations from farm granaries, farm stored grain treated with chemical preservatives, animal feed processing mills and hay, stored for animal feed were studied in Scotland. Mites were not a serious problem on grain as it was usually well dried or if stored undried it was treated with propionic acid to prevent mould growth. Mite infestations in animal feed processing were controlled by improved hygiene and more effective acaricides. Hay was invariably infested by mites, usually *Tyrophagus longior*, *Acarus farris* and *Glycyphagus destructor*, often in vast numbers, up to 1700 per gram of hay. Mite numbers were related to the quantity of fungi in hay, but mite species were not significantly related to different types of fungi. Mite population peaks followed peaks of fungal intensity and declined as the fungal food source diminished. An ecological succession of field, storage and thermophilic micro-organisms was observed. Very few mites were found on freshly cut hay but endemic populations of the species found on stored hay were collected from farm buildings. Mites and mite debris rendered airborne during hay handling in confined spaces caused respiratory allergies to sensitised workers. No effective method to eliminate fungi and consequently mites from hay was discovered. Therefore allergic workers were advised to avoid hay, take protective medication, or wear respiratory face masks.

S14.2.  
7

# STUDIES ON STORED-PRODUCTS MITES ASSOCIATED WITH BARLEY DURING CROWTH

1. N.G.EMMANOUEL, Agricult.College of Athens, Athens - Greece
2. G.O.EVANS, University College Dublin, Ireland

During investigations on aspects of the biology of mites associated with cereals during growth and storage in Co.Kildare,Ireland,thirty one species of mites were collected from the aerial part of barley grown in four plots each subject to different mechanical and cultural treatments.The most abundant and frequent of those species were:Tyrophagus longior.(Gerv.),Lupotarsonemus talpae (Schr.),Siteroptes graminisugus (Hardy), Tarsonemus confusus Ewing and Tydeus nr.mumaei Baker. Twenty species were found on the inflorescences included all the most abundant species listed above. S.graminisugus showed the greatest affinity for thw inflorescences.

Excluding Heterostigmata four species,namely Acarus farris,T.longior, T.palmarum Ouds and Glycyphagus domesticus (De Geer), found to be common in stored barley in Ireland were also recovered from barley in the field. It was concluded,however,that the major pest Acarus siro L. is an exclusively granary-mite. Two other common species of stored grain: Lepidoglyphus destructor (Schränk) and Cheyletus eruditus (Schränk) were found to be Accidental and Recedent in the field.

Generally, there was a trend for majority of the species in the field to increase with the time up to harvest.

S14.2.  
8

# STATUS OF STORED PRODUCT ACAROLOGY IN TAIWAN

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Mites' problems on stored rice and dehydrated mushroom initiated the research of stored product acarology in 1960' in Taiwan. In 1960's Tseng recorded 54 species of mites from stored rice after Tsai's reporting of 14 species of mushroom mites. More than 50 stored products were sampled for species studies during 1970's which included 13 categories, i.e. grains, sugar, honey, processed fruits,preserved and dehydrated meats, feather, dehydrated sea food, dairy products, edible fungi, preserved and prosessed vegetables, nuts, flower bulbs, garlic bulbs. A total of 80 species in 21 families of 3 suborders were recorded in stored products in which at least 50 species were of stored grain mites only. Almost half (37) of recorded mite species were predators and their population densities were corelated with their prey. Suidasia meda-nensis, Caloglyphus mycophagus, Tyrophagus putrescentiae in grains, and Rhizoglyphus robini in bulbs were the dominant groups among all stored product species and their population was active in their habitat all year round.

14

**S14.2.** INCIDENCE OF MITES ASSOCIATED WITH STORED SEEDS AND FOOD  
**9** PRODUCTS IN UPPER EGYPT

M.A.ZAHER, M.I. MOHAMED & S. M. ABDEL- HALIM

Faculty of Agriculture, Caior University, Giza, Egypt

Survey on mites associated with stored seeds, flour and food stuffs in Fayoum Governorate, Upper Egypt proved the occurrence of about 24 species. Of these , 15 species in 8 families belong to Actinedida, 6 species in 3 families belong to Acaridida and 3 species in 2 families belong to Gamasida .

Members of the families Cheyltidae and Acaridae were the most common mite found in many samples. Those of Caligonellidae , Ascidae and Raphignathidae were fairly common but in fewer numbers of materials. Samples of lupine and camomile did not harbour any mites.

**S14.2.** STORED PRODUCT MITES IN EGYPT, SURVEY AND ECOLOGY.  
**11**

MCHSEN S. TADROS , PLANT PROTECTION DEPARIMENT, FACULTY OF AGRICULTURE,  
TANIA UNIVERSITY, KAFRE EL-SHEIKH, EGYPT.

A survey was conducted to determine the most prevelant mites infesting the stored product foods in Kafre El-Sheikh region, Egypt. The selected products included, either granular products, such as wheat, barley and rice ;or ; legume seeds, such as beans, peas and lentils. The survey included some prepared food stuff used for dairy animal or chicken nourishment .

Ecological factors, that might be responsible for mite infestation in the surveyed products, were greatly considered. Some laboratory trials have been carried out to develop measurements for controlling the most prevelant mite species in the selected products.

514.3. CHEMOSENSORY BEHAVIOR OF THE CONFUSED FLOUR BEETLE, TRIBOLIUM CONFUSUM,  
1 AND THE RUSTY GRAIN BEETLE, CRYPTOLESTES FERRUGINEUS - A REVIEW

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Aggregations of flour beetles on pith discs treated with dietary extracts were observed in two-choice arenas. Feeding was measured by a photometric technique which is reviewed. Aggregation and feeding responses by the rusty grain beetle were observed on fungus-infected kernels. An ethanol extract of brewers' yeast and the water-soluble phase elicited strong aggregation and feeding responses by flour beetles. Water and ethanol extracts of flour induced aggregation but not feeding; benzene extracts induced both. An ethanol extract of bran and the water-soluble phase of this extract elicited both responses. Extracts of wheat germ with water, absolute alcohol, benzene and ether elicited powerful feeding responses. Several unsaturated triglycerides from wheat germ stimulated strong aggregation responses in flour beetles. Rusty grain beetles aggregated on wheat kernels infected with certain seed-borne fungi. The highest aggregations and the most feeding occurred on infected kernels with exposed germs.

514.3. PREFERENCE FOR  $MgSO_4$ -TREATED LEGUMINOUS SEEDS IN EGG-  
2 LAYING ACANTHOSCELIDES OBTECTUS SAY /COL., BRUCHIDAE/

Á. SZENTESI

Res.Inst.Plant Prot., Budapest, Pf.102, H-1525, Hungary

Contrary to many structurally complex and inhibitory substances of plant origin, a wide range of concentrations /0.004-1.0 M/ of a simple inorganic salt,  $MgSO_4 \cdot 7H_2O$ , applied on dry beans, significantly improved egg-laying response of A. obtectus in binary choice-tests. No other  $Mg^{2+}$ -containing compounds studied exerted such an effect, nor a similar response was noted on treated beans in no-choice situations. Variably enhanced or decreased oviposition responses were experienced on  $MgSO_4$ -treated secondary- and non-hosts or on indifferent substrates /such as glass beads, starch pilules/. It is assumed that the oviposition bias was attributed: 1. to the stimulatory effect of  $MgSO_4$  /through arrestment following gustation/, albeit, no specific behaviour was shown by egg-laying bean weevil females on  $MgSO_4$ -treated seeds, and/or 2. to sedentariness evoked by the probable uptake of  $Mg^{2+}$  ions because of their subsequent impact on the neuromuscular transmittance.



**514.3.** FEEDING PREFERENCE AND OVIPOSITION PREFERENCE OF RICE WEEVIL,  
**3** Sitophilus zeamais MOTSCHULSKY FOR RICE GRAIN.

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Rice grains were stored at different stages of the milling process using rough (paddy), brown(hulled), polished(milled), and parboiled rice. As the infestation and development of rice weevils are greatly influenced by these grain forms, the feeding preference and oviposition preference of adult S. zeamais were examined among brown, polished, parboiled-brown, and parboiled-polished rice. The feeding preference for rice grain, the feeding preference for powdered rice, and the oviposition preference for rice grain were different in the preference ranking. Results indicated the following processes:

(1)Attractive substances are contained mainly in the embryonic part and aleurone layer of a grain. (2)Pericarp inhibits the emanation of attractive substances from a grain. The milling and parboiling processes break this barrier at variable degrees. (3)The attractive substances or the sensitivity of weevils to them may be different with feeding and oviposition preferences. (4)A solid shape of grain is needed for oviposition but is not necessary for feeding. (5)Maeshima et al.(1983) showed that three kinds of chemical compound operate jointly as attractive substances for oviposition. But, these compounds showed a repellent activity when operate singly or in combination of two of them.

**514.3.** FEEDING - BEHAVIOUR AND ACTIVITY OF LARVAE OF  
**4** HYLOTRUPES BAJULUS L. (COLEOPTERA: CERAMBYCIDAE)

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The activity of Hylotrupes bajulus-larvae depends on structure of substrate. In pine-sapwood the activity-pattern is articulated in single episodes, separated by short times of very low activity. Here appearing periodicities vary between 30 and 120 minutes. In artificial diet (without structure) are only weakly signified pauses between single episodes of activity, the activity-pattern seems continuous. Here two slightly but very constant marked periodicities lasting 30 to 45 minutes and 55 to 120 minutes are proved. A short-term periodicity of nearly 20 minutes was proved in activity of all larvae both in pine-sapwood and in artificial diet, its endogene fixation has been discussed.

The behaviour of larvae tunnelling in pine-sapwood was observed and demonstrated quantitatively by measuring the force and its direction appearing at the feed of H. bajulus-larvae. Forces up to 6 Newton were shown in single bites of a larvae of 400 mg, the duration of a single bite was e.g. 0.45 seconds.

Two microcomputer-based methods for acoustic registration of activity and measuring force and its direction appearing at the feed of wood-boring insects were introduced.

14.3. ACTION OF ANTIFEEDANTS OF PLANT ORIGIN ON BEETLES  
INFESTING STORED PRODUCTS

5

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A test with wafer discs was used to examine 80 chemical compounds inhibiting food intake in the beetles *Sitophilus granarius* L. and *Tribolium* Duv. as well as in the larvae of *Tribolium confusum* Duv. and *Trogoderma granarium* Ev. These were mostly sesquiterpene lactones isolated from plants belonging to the families Compositae and Umbelliferae as well as from fungi. Five compounds /helenalin, linifolin A, bakkenolide A, lactarofurin A and bisaboloangelone/ prevented feeding of pests tested for 5 days.

The application of 50 mg and 250 mg kg<sup>-1</sup> doses of helenalin, bakkenolide A and bisaboloangelone to wheat grain reduced the food intake of the beetles and their larvae, entailed their increased mortality and decrease in their fecundity.

On a feeding-ground sprayed with these compounds insects showed increased mobility and, as a result, did less damage to the grain.

When applied to the larvae and pupae of *Tribolium confusum* and *Trogoderma granarium*, bisaboloangelone acted as a strong juvenoid.

14.3. COMPARATIVE EFFECTS OF SOME VEGETABLE OILS AS PROTECTANTS  
OF MAIZE FROM DAMAGE BY RICE WEEVILS, SITOPHILUS ORYZAE (L.)

6

IVBIJARO, M.F.; LIGAN, C.; & A. YOUDEOWEI

Oils of coconut, groundnut and African palm admixed with maize grains at 5 or 10 ml/Kg completely prevented grain damage, and the development, multiplication and survival of the rice weevils, Sitophilus oryzae (L.)

At 5-10 ml/Kg the oils caused 83-100% adult weevil mortality in treated maize within 24h, and 100% in 7 days.

Egg production, and development of weevil offspring at 1-10 ml/Kg of each vegetable oil were significantly suppressed ( $P < 0.05$ ). Emergence of offspring and grain weight loss were each positively correlated ( $r = 0.941$  for offspring), and ( $r = 0.995$  for weight loss) with grain damage. Water absorption and germination were not affected.

Coconut oil = groundnut oil > palm oil in reducing kernal damage, frass production and weight loss in treated seeds. Each oil was significantly superior to the control.

S14.3.  
7

INSECTICIDE REPELLENCY IN THE RUST-RED FLOUR BEETLE (T. CASTANEUM)

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ENGLAND.

The repellency of stored product insecticide formulations to resistant and susceptible strains of T. castaneum was assessed in choice arenas.

All strains of flour beetle were repelled by insecticidally treated surfaces, but resistant insects demonstrated higher levels of avoidance than susceptible insects.

The formulation carriers of wettable powder formulations proved particularly repellent, and beetles could differentiate between differently dosed areas. The beetles avoided higher dosed areas.

The contribution of physiological resistance to behavioural resistance is considered and the role of insect learning in survival of residual insecticide treatments is discussed.

S14.3.  
8

TEMPERATURE - SENSITIVITY OF THE SYMBIONTS, A LIMITING FACTOR FOR THE OCCURENCE OF ANOBIUM PUNCTATUM (DE GEER);  
COL., ANOBIIDAE

CYMOREK, S.

DESOWAG-BAYER HOLZSCHUTZ GMBH, F+E-Zentrum, Krefeld-Uerdingen

Observations of larvae after heat-treatment (2), as well as breeding under different conditions, has revealed a temperature-sensitivity fatal to the yeast-like symbionts (Torulopsis or Symbiotaphrina (3)) within the known limits of the temperature-range for development (1). Larvae in wood at  $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$  showed the first disturbances in symbiosis after 6 weeks, and shrinkage and death within 2-3 months. - In holomeridic diets, at  $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$  and 75 % rel. humidity, recently hatched larvae developed successfully and fast without establishing symbiosis at all; at  $21^{\circ}\text{C} \pm 1^{\circ}\text{C}$  symbiosis was established as usual. Development of recently hatched larvae at  $30^{\circ}\text{C} \pm 1^{\circ}\text{C}$  was poor and slow, but possible. - Thus the abiotic factors, temperature and humidity, and the biotic factors, nourishment and symbiosis, form (1.) a net of interdependencies in which (2.) the temperature-sensitivity of the symbiont forms a substantial limiting factor and (3.) must influence the level of occurrence and the geographical distribution of the "Common Furniture Beetle".

(1)-Becker, G., 1943: Z. angew. Entomol., 30 (1). 104-118

(2)-Cymorek, S., 1971: Mitt. Deutsch. Ges. Holzforsch., Nr. 57: 50-57

(3)-Jurzitza, G., 1979, in Batra (ed.): Proc. 2nd Int. Mycol. Congr., Tampa, Florida, 1977: 65-76

S14.4.  
1

## STORED PRODUCT INSECT PHEROMONES AND TRAPS: SOME RECENT DEVELOPMENTS

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Male-produced aggregation pheromones predominate in the long-lived grain beetles such as the Sitophilus weevils and Rhyzopertha dominica, the lesser grain borer. Pheromones of these and other grain and warehouse beetles will be discussed. Several new trap designs for use in grain storages, food processing facilities and warehouses will be discussed. A newly designed plastic grain-probe insect trap, a pitfall device to insert in grain, may contain either pheromones or food attractants or both. A newly designed corrugated cardboard trap contains a central well or dish that also serves as a pitfall trap. The dish contains an oil-based lure that both attracts and kills the insects. Various pheromones may be placed in the trap and next to the oil dish. These traps therefore do not require either pesticides or adhesive materials. Managers of food processing and storage facilities as well as pest control operators have recently been utilizing these pheromones, attractants and traps with considerable success in monitoring insect populations. Insect monitoring and control systems by these techniques will be discussed.

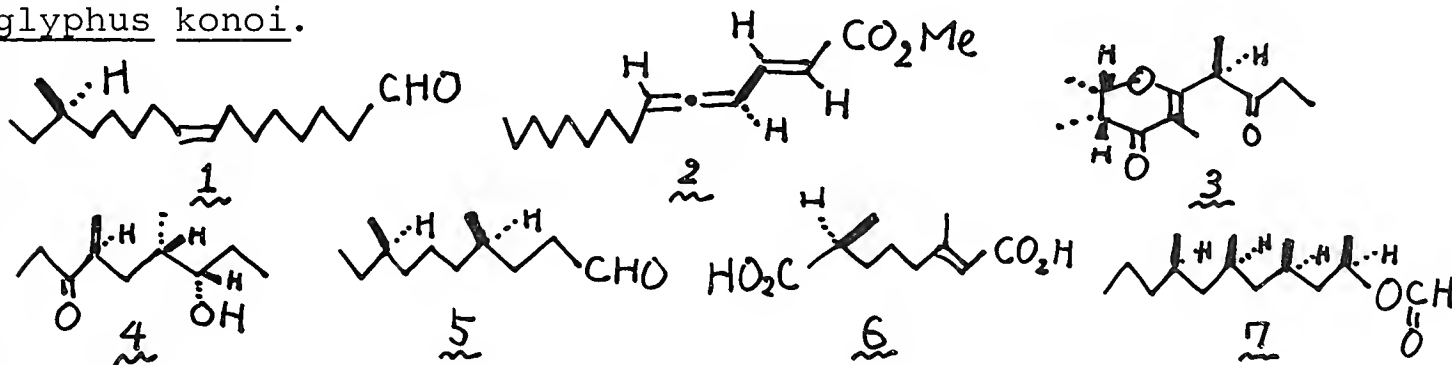
S14.4.  
2

## RELATIONSHIP BETWEEN STEREOCHEMISTRY AND PHEROMONE ACTIVITY IN STORAGE INSECT SPECIES

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Capability of synthetic chemists to provide pheromone stereoisomers in high optical purity enabled entomologists to study the relationship between stereochemistry and pheromone activity. The pheromones of the following insects and an acarid mite will be discussed : 1 khapra beetle, 2 dried bean beetle, 3 drugstore beetle, 4 cigarette beetle, 5 red flour beetle, 6 azuki bean beetle, Callosobruchus chinensis, and 7 the acarid mite, Lardoglyphus konoi.



S14.4.  
3

#### PHEROMONE-MEDIATED AGGREGATION IN CUCUJID GRAIN BEETLES

J.H. BORDEN, A.M. PIERCE, H.D. PIERCE, JR., A.C. OEHLISCHLAGER, AND J.G. MILLAR, CENTRE FOR PEST MANAGEMENT, DEPARTMENT OF BIOLOGICAL SCIENCES, SIMON FRASER UNIVERSITY, BURNABY, B.C., CANADA, V5A 1S6.

Orientation and pitfall bioassays have disclosed the presence of aggregation pheromones in cucujid beetles in the genera Cryptolestes and Oryzaephilus. Capture and analysis of volatiles from confined infestations of these beetles has resulted in the identification of a new class of closely related macrolide pheromones. Within the group of species studied, there is evidence for discrimination between optical isomers of aggregation pheromones, synergism between pheromones, and species specificity based on pheromone blends. Synthetic pheromones have proven to be attractive in laboratory and simulated field bioassays, some of which utilize a new, transparent chamber trap, that facilitates identification and counting of captured beetles. There is considerable potential for application of these pheromones in detection and monitoring of populations in stored grain and food products.

S14.4.  
4

#### SYNTHESIS OF MACROLIDE AGGREGATION PHEROMONES OF CUCUJID GRAIN BEETLES

A.C. OEHLISCHLAGER, J.G. MILLAR, J. WONG, A.M. PIERCE, H.D. PIERCE, JR., V. VERIGIN AND R. STRUB, Department of Chemistry, Simon Fraser University, Burnaby, B.C., Canada V5A 1S6

Seven macrolide aggregation pheromones for five species of cucujid grain beetles in the genera Cryptolestes and Oryzaephilus have been synthesized by routes involving intramolecular lactonization of the appropriate hydroxy acids. The routes chosen allowed the introduction of chiral centres in the four macrolides possessing chirality. Three of the macrolides possess a Z,Z-skipped diene system.

**S14.4.**  
**5** AGGREGATION PHEROMONE IN *Dermestes maculatus*

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Observations on the effect of an aggregation pheromone of *Dermestes maculatus* indicate the production and liberation with faeces of two different compounds of a primer type. One is produced by larvae themselves and accelerates growth, the other is produced by adults and inhibits larval development. Both larval and adult pheromones synchronize larval ecdyses.

In further experiments it was found that the juvenile hormone (JH) increases significantly the reaction of males to an aggregation pheromone. The reaction of females is much less pronounced which is probably due to the differences in endogenous levels of the JH of both sexes. The same treatment given to the sixth (last) instar larvae prolongs duration of this period and the aggregative reaction of these larvae remains at the high levels for much longer time than of the controls larvae treated with solvent only.

**S14.4.**  
**6** A SEX PHEROMONE - PRODUCING GLAND FOUND IN FEMALE  
*Lasioderma serricorne* [Fabricius]

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A lobate exocrine gland producing a sex pheromone was discovered below the alimentary canal and close to the ventral epidermis of the second abdominal segment of virgin females of the tobacco beetle [*Lasioderma serricorne* F.], while no pheromone gland could be found in the males of this species. The gland duct extends to an orifice below the genital pore and is supported by a rigid invagination [V-shaped apodeme] of the integument.

Hexane extracts of male abdomina are not attractive to male or female tobacco beetles and failed to induce significant receptor potentials in their antennae, whereas extracts of female pheromone glands are attractive to unmated male *L.serricorne* and evoke dosage-dependent receptor potentials in their olfactory sensilla. The degree of response of unmated males to the female sex pheromone is age-dependent. The sex pheromone tends to accumulate in the cuticle lipids of virgin females of *L. serricorne*.

S14.4.  
7

#### RECENT RESEARCH ON THE CHEMISTRY OF LASIODERMA PHEROMONES

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The sex pheromone produced from female cigarette beetle (*Lasioderma serricornis* F.) was isolated and the structure was elucidated as 4,6-dimethyl-7-hydroxy-nonan-3-one (serricornin) by spectroscopic evidence and the synthesis of the diastereomeric mixture. The absolute stereochemistry of serricornin was established to be (4S,6S,7S) by a series of stereoselective synthetic studies. The behavioural and EAG studies on the structure-activity relationship of serricornin revealed that the (4S,6S,7S)-absolute configuration in the natural serricornin was essential to elicit the strong sex pheromone activity for male cigarette beetle. Recent investigation of the sex pheromone components in the excreta of female indicated the presence of six minor components and their structures were elucidated as 4,6-dimethyl-7-hydroxy-4E-nonen-3-one, 4,6-dimethyl-nonan-3,7-dione, 4,6-dimethyl-nonan-3,7-diol, 3,4-dihydro-2,6-diethyl-3,5-dimethyl-2H-pyran (anhydroserricornin), 2,3-dihydro-3,5-dimethyl-2-ethyl-6-(1-methyl-2-oxobutyl)-4H-pyran-4-one (serricorone) and 2,3-dihydro-3,5-dimethyl-2-ethyl-6-(1-methyl-2-hydroxybutyl)-4H-pyran-4-one (serricorole).

The biological roles of these components in the copulation behaviours of this insect and their occurrences related to polyketide biosynthesis will be discussed.

S14.4.  
8

#### MONITORING OF THE CIGARETTE BEETLE IN TOBACCO MANUFACTURING BY MEANS OF PHEROMONE TRAPS

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Pheromone traps baited with ( $\pm$ )-serricornin (S) synthesized by Fuji Flavor Co. were evaluated in tobacco processing areas for effectiveness in capturing and monitoring the cigarette beetle (CB), *Lasioderma serricornis* (F.). Pheromone traps were compared with conventional electric grid traps (EGT) and Biolure™ (B) sticky traps. During a 1 year experiment 59, 166 and 1083 CB were caught using EGT, B and S, respectively. When compared with the number of CB caught in EGT, pheromone traps captured 18 times as many. A 1:1 male to female sex ratio was observed in B catches, however, S showed a 9:1 ratio.

Data from pheromone traps can be a useful tool for monitoring CB populations in areas where insecticide applications are either impossible or difficult. The flexibility of pheromone trap placement will be discussed.

S 14. 4.  
9

PHEROMONAL MONITORING OF THE GREATER GRAIN BORER  
PROSTEPHANUS TRUNCATUS (HORN)

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Prostephanus truncatus (Coleoptera, Bostrichidae) is a recently introduced and serious pest of farm stored maize and cassava in Tanzania. It is spreading both within and across the borders of that country.

A pheromone trap for monitoring this pest is being developed. Components of the aggregation pheromone of Rhyzopertha dominica (Fabricius) have been tested in the laboratory and field. Traps baited with one of the components and placed in farm maize stores demonstrated the presence of the beetle as frequently as visual inspection. Preliminary investigations of a specific P. truncatus pheromone suggest that this material would be an even more effective bait.

S 14. 4.  
10 CERTAIN FACTORS INFLUENCING SEX PHEROMONE PRODUCTION  
AND PERCEPTION BY TRIBOLIUM CASTANEUM (HERBST)

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Sex pheromone production by T. castaneum (Herbst) was adversely affected by rearing beetles at low temperatures. It increased at higher rearing temperatures and reached its maximum titer at 30 - 40°C. In the early morning pheromone production was low. It started to increase during day time, and reached its maximum titer at 3.00 p.m. Later on, it decreased again and was lowest by night. The peak of male response occurred between 1:00 and 3:00 p.m. Irradiation of female beetles with increasing doses of gamma radiation ( 4-10 Krad ) considerably decreased sex pheromone production. Males were more radiosensitive in their perception. Irradiated pupae produced beetles that were much more radiosensitive than irradiated adults in pheromone production and perception.



**S14.4.** ROLE OF QUINONES AND PHEROMONES IN CONTROL OF TRIBOLIUM CASTANEUM  
**11** (HERBST) LARVAE (COLEOPTERA:TENEBRIONIDAE).

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Department of Agricultural Biology,  
The University, Newcastle upon Tyne, NE1 7RU, U. K.

The roles of synthetic methylquinone (2-methyl-1,4-benzoquinone) and aggregation pheromone (4,8-Dimethyldecanal) in control of T. castaneum larval population were studied. Results indicated that larvae of T. castaneum were repelled both by contact and vapour of 2-methyl-1,4-benzoquinone, while they were attracted both by contact and vapour of 4,8-Dimethyldecanal. Both these chemicals prolonged the larval period and reduced larval growth. They reduced adult emergence, and induced deformity in adults. The fecundity and fertility of females emerging from treated larvae were also reduced. Methylquinone in combination with insecticide acted as a synergist increasing the mortality of the larvae.

These results are discussed in relation to the potential use of quinones and pheromones in control of Tribolium.

**S14.4.** RÔLE OF PHEROMONE AND OPTICAL STIMULI IN THE SEX ATTRACTION  
**12** OF STORAGE MOTHS [Phycitinae]

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Olfactory responses to [Z,E]-9,12-tetradecadienyl acetate [TDA], [Z]-9-tetradecenyl acetate [TA] and [Z,E]-9,12-tetradecadienol [TDO] were recorded from single sensilla trichodea of the antennae of male Anagasta kuehniella [Zeller], Ephestia elutella [Huebner] and Plodia interpunctella [Huebner]. The patterns of receptor potentials and nerve impulses following stimulation by the above pheromone components suggest their perception by two distinct types of receptor cells: one responding to TDA and TA and one reacting to TDO alone.

Electrophysiological recordings from the eyes of the above phycitid species revealed a high retinal sensitivity to low intensities of light [0.05-1.0 Lux]. Stimulation by light is required by male flour moths for flying upwind to a pheromone source. Male P.interpunctella and Cadra cautella [Walker] are capable to differentiate between rectangular, quadratic and circular configurations and fly preferably to narrow rectangles in vertical suspension. A close interaction between figural and pheromone stimuli was demonstrated in the courtship flight of those phycitid species.

**514.4.** THE POPULATION DENSITY OF *Ephestia elutella* [HUEBNER] IN A  
**13** TOBACCO STORE IN SOUTHERN GREECE: A TWO YEAR'S SURVEY BY  
PHEROMONE TRAPS

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1) Benaki Phytopathological Institute, Kifissia, Athens, Greece

2) Max-Planck-Institut für Verhaltensphysiologie, Seewiesen, FRG

The population density of *Ephestia elutella* of a tobacco store in Piraeus, Greece, was studied by weekly recordings of moth catches on adhesive pheromone traps, in a survey extending for two years. The traps were baited with dosages of 100 µg of [Z,E]-9,12-tetradecadien-1-yl acetate [TDA] per polyethylene capsule or were left unbaited [control traps]. During the survey, the storage rooms were not treated by any insecticide.

On base of the number of *E. elutella* caught by pheromone and control traps we may conclude that the TDA traps lured the majority of male tobacco moths available in the above tobacco store. The use of pheromone traps in tobacco stores provides a convenient procedure for population surveillance and timing of control measures. Continual mass trapping of *E. elutella* may eventually induce insectistasis of the tobacco moth population, whereby the number of control measures can be reduced.

**14.4.** PRACTICAL USE OF PHEROMONES IN WAREHOUSES FOR THE CONTROL OF PHYCITINAE  
**14** MOTHS IN FRANCE.

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The practical use of pheromone of phycitinae moths for detection and monitoring in traditional storage premises are investigated. The comparative efficiency of mating disruption techniques and mass trapping for monitoring moth infestation is discussed. The results in practical application in storage and manufacturing facilities of new cheap trap design baited with synthetic pheromone is presented.

The ability to detect and to control low levels of infestation of moths has been observed in the laboratory and in storage premises of stored dried prunes and of seeds.

**P14.-**  
**1** SEX RATIOS, REPRODUCTIVE VALUES AND REGULATION OF NUMBERS  
OF GRANARY BEETLES POPULATIONS /*Sitophilus granarius* L. and  
*Oryzaephilus surinamensis* L./.

ZOFIA CIESIELSKA

Institute of Biology, Pedagogical University, Cracow, Poland

This work is a continuation of the previous research revealing the mechanisms which regulate the number of individuals within a population. *Sitophilus granarius* L. was nourished mainly on wheat, whereas semolina constituted the integral part of food supply used for feeding *Oryzaephilus surinamensis* L. The diet was supplemented with  $MgSO_4$ , the concentration of which was 0,001%, 0,1% and 1% respectively. Some populations were given yeast as additional food which constituted 0,1%, 1% or 5% of the whole food substance. In numerous repetitions of experiment, an increased number of individuals was observed within those populations in which  $MgSO_4$  was used as a supplementary ingredient, as well as within those nourished on yeast. The analysis of reproductive value rates and sex rates in periods preceding changes in population numbers led to the conclusion that there exists correlation between the drop in population numbers and changes not only of the sex structure of the population but also of reproductive value rates.

**P14.-**  
**2** CHEMICAL AND PHYSICAL DEFENCES OF CROP AND WILD LEGUMES AGAINST  
BRUCHIDS

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Jodrell Laboratory, Royal Botanic Gardens, Kew, RICHMOND,  
Surrey, TW9 3DS ENGLAND.

"Chemical and physical defences of crop and wild legumes against bruchids".

Research is in progress to investigate interactions between pest bruchids *Callosobruchus maculatus* Fabr. and *C. chinensis* L on a wide range of legume host and non-host seeds. Chemical and physical factors included are:- (i) seed testa characters influencing oviposition behaviour; (ii) testa characters influencing embryo development and larval entry; (iii) endosperm and cotyledon characters affecting larval development and (iv) factors affecting adult emergence, survival and behaviour. The possible rôles of surface waxes and volatiles, rotenoids, trypsin inhibitors, lectins and glycosidase inhibitors are discussed.

Section 15	Medical and Veterinary Entomology .....
R 15.1.	<i>Culex pipiens</i> Complex .....
R 15.2.	<i>Mosquito Ecology</i> .....
R 15.3.	<i>Mosquito Control</i> .....
R 15.4.	<i>Simuliidae</i> .....
R 15.5.	<i>Biting Flies</i> .....
R 15.6.	<i>Phlebotominae and Other Groups</i> .....
S 15.1.	<i>Strategies for the Integrated Management of Cattle Warble Grub</i> <i>(Hypoderma spp.) Populations</i> .....
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S 15.5.	<i>Sixth Meeting of the World Ceratopogonidae Study Group</i> .....
S 15.6.	<i>Visual Orientation of Hematophagous Diptera</i> .....
P 15.	.....
F 15.	.....

R15.1.  
1

STATUS OF "Culex pipiens pallens" IN THE Culex pipiens COMPLEX

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"Culex pipiens pallens Coquillett, 1898" is believed to be distributed in southeastern Asia, in Japan, the Korean peninsula and northern parts of mainland China. However, the taxonomic status of "C. p. pallens" especially its relationship to C. p. pipiens, C. p. quinquefasciatus and the intermediate form between these two species that occurs in California and other parts of the United States, is controversial.

Larval and adult characters of mosquitoes that belong to the C. pipiens complex are compared by examining specimens collected from various localities of Japan, Korea, China, the United States, Canada, England, Germany and other parts of the world.

Every character of larvae and adults of "C. p. pallens" so far examined in this taxonomic study is intermediate between C. p. pipiens and C. p. quinquefasciatus and the two extremes of "C. p. pallens" could not be distinguished from the two other subspecies. Therefore "C. p. pallens" should not be treated as a distinct subspecies.

Some ecological characters of the members of the C. pipiens complex in the world will also be compared.

R15.1.  
2

MORPHOMETRIC STUDIES OF DIFFERENT STRAINS OF CULEX PIPPIENS S.L.

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Seventeen different strains of the Culex pipiens complex, collected in Europe, Africa, N. & S. America, and Asia have been studied for differences in their morphology. Particular attention was paid to features such as the palpus, proboscis, antenna, thorax, midtibia and wings. Analysis of the data obtained confirmed the possibility and morphological separation between C. pipiens, C. molestus and C. quinquefasciatus. Furthermore, there was some evidence that S. E. Asian strains of C. quinquefasciatus are distinct from those from Africa and America. Also it was possible to separate European from African strains of Culex molestus. One African strain could be distinguished from all other C. molestus.

**R15.1.** MATING COMPETITIVENESS OF TRANSLOCATION HETEROZYGOTE MALES  
**3** OF CULEX.P.QUINQUEFASCIATUS IN LABORATORY CAGE TRIALS.

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Chromosomal translocations are of importance in genetic control of insect pests. 10 sex-linked and 20 autosomal radiation induced chromosomal translocations have been isolated in C.p.Quinquefasciatus, one of the important vectors of Bancroftian filariasis in Asian Countries (Shetty, 1982, 83). C.p.quinquefasciatus males, heterozygous for a double translocation designated T(1;2;3)25 were tested for their potential use as a genetic control mechanism. The above line has passed through 15 generations and was showing constant levels of semisterility (78±10%) with high viability. T(1;2;3)25 males mated with females of 3 different strains (two from the laboratory stocks and one from the field collected females) while in the competitive presence of normal males. The mating competitiveness of translocated males was estimated to be at 1.0 or higher level. Thus, the line T(1;2;3)25 could be used in the field trials involving the control of C.p.quinquefasciatus.

**R15.1.** ANNUAL CHANGES IN NUMBER OF EGG-RAFTS OF CULEX PIPIENS  
**4** COMPLEX IN ABOVE-GROUND WATER IN NAGASAKI CITY

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Investigations have been made for annual changes in number of egg-rafts of Culex pipiens complex, Culex pipiens pallens and Culex pipiens molestus, laid on the above-ground water (open water) since 1962 in Nagasaki City. The number of egg-rafts had rapidly decreased for period from 1962 to 1972, and thereafter it has not changed considerably. After 1976 it was found that the egg-rafts of Cx. p. molestus were usually collected on the above-ground water. Most of the egg-rafts collected from 1962 to 1972 were estimated to have been laid by Cx. p. pallens females. The reduction of the egg-rafts appears to be due to the fact that main breeding sites for Cx. p. pallens have decreased because of urbanization, such as the pavement of the roads. The above-ground oviposition activity of Cx. p. molestus is considered to have occurred with increase of cesspools which are main breeding places.

**R15.1.**  
**5** EFFECTS OF TEMPERATURE ON SOME ATTRIBUTES ON THE HYBRID  
BETWEEN CULEX PIPIENS PALLENS AND CULEX PIPIENS MOLESTUS.

MORI, A. and ODA, T. (Dep. Med. Zool., Nagasaki Univ. School of Med., Nagasaki, 852 - Japan)

Few records of the collection of mosquito seem to be such "hybrid" in Japan. The hybrid is produced by the cross between molestus females and pallens males. Before looking for the hybrid in the field, it seems that characters of them have to be clarify. Experimental hybrids between molestus females and pallens males were reared under experimental conditions with various temperatures and the effect of temperature on some attributes was observed. At low temperature autogenous females commonly emerged, and many females had 8 ommatidia in the 4th, 5th and 6th row of compound eyes. Two attributes in these females are similar to molestus females. At high temperature the attribute in the females were generally similar to pallens females, that is they were unautogenous and had 9 ommatidia.

**R15.2.**  
**1** CHANGES IN MOSQUITO FAUNA CAUSED BY ENVIRONMENTAL MODIFICATIONS

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Both intentional and unintentional modifications to the environment are resulting in some dramatic changes in the mosquito fauna in many parts of the world, especially in the developing countries. It is well known, for example, that urbanization has resulted in the proliferation of Culex quinquefasciatus in many towns, and that the malaria vector Anopheles stephensi has become well adapted to breeding in wells, cisterns and other domestic containers in urban areas of India and Pakistan. In other areas irrigation schemes have caused increased populations of Anopheles mosquitoes, and also certain culicine vectors such as Cx. tritaeniorhynchus and Cx. univittatus, moreover the increased humidity experienced on some large irrigation schemes may assist in extending the survival rates of mosquito vectors. In the semi-desert area of the Kunduz Valley in Afghanistan irrigation has altered the ecology of the area and, as a consequence, An. hyrcanus and An. pulcherrimus, both important malaria vectors, are now common man-biting mosquitoes. In other areas deforestation has also drastically changed the mosquito fauna, and sometimes led to increased transmission of malaria and other vector-borne diseases.

**K 15.2.** SEPTIC-TANK BREEDING MOSQUITOES: COMPETITION  
**2** BETWEEN SPECIES IN JOS, NIGERIA.

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Emergence traps placed over septic-tank vents were used to examine the relative abundance of species over the savanna dry season. Preliminary findings, supported by an experiment on the colonization of containers in the same area, showed that two other species compete with Culex quinquefasciatus in exploiting covered, sewage-rich water. In the early dry season, Cx. decens and Cx. cinereus were more prevalent in septic-tanks than Cx. quinquefasciatus, while Cx. decens, Aedes aegypti and Ae. vittatus were competing with Cx. quinquefasciatus in dark, covered buckets of septic tank water in the early wet season.

During collections of Cx. quinquefasciatus in the following year for mark-recapture studies, it was observed that over the wet season, Cx. tigripes replaced Cx. quinquefasciatus as the most abundant species emerging from septic-tanks; in addition, the mark-recapture results indicated that even in the wet season, septic-tanks represented the major breeding site for quinquefasciatus. Apparently the Cx. quinquefasciatus population in Jos is experiencing fierce competition from other species which have also become adapted to sewage-polluted water in dark places.

**R 15.2.** OVIPOSITIONAL RESPONSES OF AEDES COMMUNIS (DIPTERA:CULICIDAE) FOR  
**3** BREEDING WATERS

ALAIN R MAIRE

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C P 500, TROIS-RIVIERES, QUEBEC, CANADA G 9 A 5 H 7

Gravid females of Aedes communis, a holarctic univoltine snow-melt Aedes are positively attracted by larval holding waters. The larval effect is stable at room temperature and may be due to volatile compounds. There is also an attractive effect of natural breeding waters on oviposition. Experiments involving respectively the chemical degradation and the microbial degradation of a deciduous litter indicate a positive effect of the two factors but the attraction due to bacterial activity is significantly higher. There is an interaction between these three types of factors. Ecological consequences of these responses in the selection of oviposition sites by snow-melt Aedes is discussed.



**R15.2.** MOSQUITOES BITING MAN AT NIGHT IN CITIES OF LIBERIA AND THEIR  
**4** SUSCEPTIBILITY TO INFECTIONS WITH WUCHERERIA BANCROFTI

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Human filariasis in this country is still a rural disease and anophelines are the proven vectors. It is uncertain whether transmission can spread into the cities where anophelines are much less numerous and *Culex quinquefasciatus* (p. *fatigans*) is the predominate species occurring in large and increasing densities. To investigate this possibility and to estimate the risk of such development night collections of mosquitoes attacking man were performed over three years. Some 17 500 mosquitoes belonging to 13 species (*Anopheles gambiae*, *melas*, *nili*, *ziemanni*; *Culex antennatus*, *decens*, *poicilipes*, *quinquefasciatus*, *thalassius*, *Mansonia africanus*, *uniformis*; *Aedes aegypti*, *Ae. sp.*) were caught and checked for filarial infections. Offspring of these mosquitoes was raised and 4438 females were challenged experimentally with *W. bancrofti*. All three anophelines and five culicines tested did allow the development and maturation of microfilariae ingested. *Culex antennatus* was the most susceptible species and *Cx. quinquefasciatus* the least susceptible one, apart from *Aedes aegypti*. On account of its high susceptibility and its considerable biting densities *Cx. antennatus* might be suspected to become a local vector of urban filariasis.

**R15.2.** FILARIASIS IN EGYPT: I. MOSQUITO BIONOMICS IN RELATION TO  
**5** WUCHERERIA BANCROFTI TRANSMISSION

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During 1982 - 1983 adult mosquitoes comprising three genera and six species were collected during weekly resting and biting collections in a village with relatively high human filaria endemicity. Emphasis was directed towards studying the bionimics of the prevalent species to assess their potential role in *W. bancrofti* transmission.

Based on a comparison between the different collecting techniques; the abundant mosquito species (*Culex pipiens*, *Culex antennatus* and *Culex univittatus*) were found to rest indoors feeding mainly on humans indoors and outdoors with one or two peaks of biting according to the species. *Culex pipiens* populations were abundant throughout the whole year with a peak during summer and fall seasons. *Cx. antennatus* was common during the summer and fall seasons while *Culex univittatus* was present only during the summer season.

Results obtained in addition to the estimated vectorial capacity of candidate vectors are discussed in relation to filaria transmission.

**R15.2.** MOSQUITO VECTORS OF DOG HEARTWORM IN AUSTRALIA  
**6**

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Transmission of dog heartworm appears to be increasing in many parts of Australia, but very little is known of which mosquitoes are vectors.

A study was designed to investigate vectors in an area, on the outskirts of Sydney, where transmission was known to be occurring.

The study area was bio-ecologically more representative of a semi-rural than an urban environment, and a preliminary mosquito survey recorded 15 species in the immediate area of a dog pound upon which the investigation was centred.

Mosquitoes were subsequently trapped over a summer using carbon-dioxide traps and dissected for developing filaria. Seven species were naturally infected, and construction of vector potential indices indicated that Culex annulirostris and Aedes notoscriptus were the primary vectors, Anopheles annulipes and Culex quinquefasciatus could be secondary vectors, and Aedes alboannulatus, Aedes rubrithorax and Culex australicus were likely to play only a minor role in transmission. Local factors will determine the relative significance of these results for other areas - coastal, inland, urban or rural.

**R15.2.** AVAILABILITY AND UPTAKE BY MOSQUITOES OF MICROFILARIAE  
**7** OF WUCHERERIA BANCROFTI

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A series of feeding experiments was carried out to elucidate possible differences in the numbers of microfilariae available to the mosquito sucking blood. Distribution of microfilariae in different areas of the human body, influence of saline injected by the mosquitoes into the skin and high or ultralow microfilaria densities are considered. Quantitative observations on the numbers of microfilariae ingested by different mosquito species feeding at the same time, spot and microfilaria-carrier were made as well as on the fate of the microfilariae when passing the pharyngeal armatures and when coming in contact with the midgut fluid of the mosquitoes.

**R15.2.** STUDIES ON INDIAN DENGUE HAEMORRHAGIC FEVER IN GURGAON CITY  
**8** (HARYANA), INDIA WITH SPECIAL REFERENCE TO VECTOR DENSITY.

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From May, 1983 until September, 1983 the adult population of Dengue Haemorrhagic fever vectors *Aedes aegypti* were monitored in all the localities of Gurgaon city of Haryana state. A total of 13924 mosquitoes belonging to 5 species of 3 genera were collected. Of this total 2.8% were *Aedes aegypti* mosquitoes. The highest resting man hour density(4) was recorded in the month of August, 83.

**R15.2.** A FEBRILE CASE OF MOSQUITO BITE  
**9**

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A 10-year-old girl had suffered from edematous erythema with hemorrhagic central vesiculation and high fever of two days' duration after the mosquito bites since 5 or 6 years of age. The biting tests, using four mosquito species, Culex tritaeniorhynchus, Aedes aegypti, Armigeres subalbatus and Anopheles sinensis, were done to make clear the causative species. She had high fever, temporal lymphocytopenia and severe eruptions 12 hours after the bite of Aedes aegypti and 20 hours after the bite of Armigeres subalbatus, while only slight erythematous lesions were noted after the bites of Culex tritaeniorhynchus and Anopheles sinensis.

The biopsy specimen from the bited site revealed hemorrhage, vasodilatation, necrotizing vasculitis and inflammatory infiltration of neutrophils and lympho-histiocytes. These findings were compatible with an Arthus type reaction.

The relation between severe cases of the mosquito bites and malignant histiocytosis in Japan will be discussed.

**R15.2.** NUISANCE CHIRONOMIDS IN THE LAGOON OF VENICE  
**10**

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Comune di Venezia, Assessorato all'Ambiente

Since May 1983 Venice City Council has been carrying out a survey to determine the species composition and the distribution of chironomids in the central basin of Venice Lagoon, where they cause annoyance to the population.

Benthic larval samples collected monthly by means of a Mozzi dredge in 32 sampling sites and adult samples revealed that only Chironomus salinarius Kieff. is present in massive amount. The larval densities gathered allow to locate two main hotbeds. Larval growth of the population of Chironomus salinarius living in the Lagoon of Venice is described.

**R15.3.** URBAN VECTOR CONTROL  
**1**

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Studies made on urban vector control services in twenty-six cities involving all WHO regions indicated an increase in vector control problems associated with inability of essential health services to keep pace with city growth. There is a need for greater priority to be given to the construction and maintenance of piped water supplies, sewerage systems and drains. Insecticides for urban vector control are largely as formulations to be applied for larviciding and space-spraying.

**R15.3.** FEASIBILITY OF MOSQUITO CONTROL BY NON-INSECTICIDAL  
**2** METHODS IN MALARIA ENDEMIC AREAS OF GUJARAT, INDIA

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FIELD STATION, NADIAD-387001, GUJARAT, INDIA.

Gujarat state is endemic for malaria. The main vector Anopheles culicifacies has become resistant to DDT and BHC. In some areas it has also become resistant to malathion. As a result of insecticide resistance and high cost of insecticidal spraying, malaria control is not fully effective. Besides, the spraying operations have to be carried out on regular basis which is also resulting in the environmental contamination. In view of this situation a study has been undertaken to demonstrate mosquito control by alternative strategy such as source reduction, minor engineering works, biological control using the indigenous fishes and soliciting peoples' participation. Initially a population of 30,000 living in the malaria endemic villages has been taken for this demonstration. Preliminary results have shown that while the density of mosquitoes is increasing in the control villages, the densities in the experimental villages have not shown any significant increase. The study is aimed to interrupt malaria transmission during the peak transmission season. Salient features of the alternate strategy would be discussed in relation to malaria control in India.

**R15.3.** Filter Feeding Rate of Aedes vexans Larvae (Diptera, Culicidae):  
**3** Implications for Control with Stomach Toxins

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In laboratory experiments, the feeding rate of fourth instar Aedes vexans larvae (Diptera, Culicidae) was estimated by measuring the amount of ingested particles per time. Nutrient particles (fishmeal, yeast, wheat flour) were ingested 3 to 6 times faster than inert particles (kaoline, pumice, talcum). In the presence of aqueous fishmeal extract, inert particles were ingested as quick as nutrient particles, proving chemical stimulation of feeding activity.

Using homogenous wheat flour suspensions with a maximal particle size of 40  $\mu$ m, the filter feeding rate (volume of water, filtered particle free by one larva/time) was estimated. As related to length of starvation period prior to exposure to test suspensions, the filter feeding rate increased from 35  $\mu$ l/larva/min without prestarvation to 92  $\mu$ l/larva/min after 12 or more hours of starvation. As related to temperature, the filter feeding rate ranged between 35  $\mu$ l/larva/min (15 °C) and 98  $\mu$ l/larva/min (28 °C), after a starvation period of 16 hours.

Thus, the ingestion of particulate stomach toxins by mosquito larvae is influenced by phagostimulants, starvation conditions of larvae and water temperature. The influence of these factors on biotests and field applications is discussed.

**R15.3.** EFFECT OF MOSQUITO LARVAL CADAVERS ON TESTS OF MICROENCAPSULATED  
**4** FORMULATIONS OF BACILLUS THURINGIENSIS (SEROTYPE H-14).

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Possible mechanisms influencing the activity of Bacillus thuringiensis (Serotype H-14) in mosquito larvae and larval cadavers were studied. In one experiment, test vessels containing cadavers of Aedes aegypti (L.) larvae exposed to a lethal dose of the H-14 serotype (IPS-78) were assayed at various intervals following treatment. Cadavers clearly enhanced activity, but the effect was not manifested unless they were at least 48 hours old. In a second experiment, vessels were treated with a single dose of the H-14 serotype equivalent to one of 3 rates, 2X, 4X or 8X the acute  $LC_{50}$  previously determined for 25 Ae. aegypti larvae. A commercially manufactured formulation was compared with the same material microencapsulated in a polymer matrix during this experiment. During the 6-month period following treatment of test vessels, more than 5,000 larvae were exposed--cadavers were not removed. Even at the lowest application rate, mortality exceeded 99%. Elucidation of this phenomenon resulted in the identification of some design criteria for experiments with controlled release formulations of the H-14 serotype.

**R15.3.** EFFICACY OF BACILLUS SPHAERICUS H-26 AGAINST THE  
**5** LARVAE OF ANOPHELES CULICIFACIES

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A strain of Bacillus sphaericus H-26 was isolated from the diseased Anopheles larvae and tested for the larvicidal activity against different instar larvae of Anopheles culicifacies, vector of malaria. The results of daily percentage mortality showed 100% mortality occurred within 48 hours of incubation at  $3.6 \times 10^4$  spores/ml in the 1st instar larvae, 100% mortality was caused at  $7.2 \times 10^4$  spores/ml after 96 hours in 2nd and 3rd instar larvae. The  $LC_{50}$  values for all instar larvae showed  $5.2 \times 10^3$ ,  $2.4 \times 10^4$ ,  $4.7 \times 10^4$  spores/ml for 1st, 2nd and 3rd instar larvae respectively.

**R15.3.****6**STRATEGIES FOR OPTIMIZING Bti AND MONOMOLECULAR FILM IN  
INTEGRATED MANAGEMENT OF RICELAND MOSQUITOES IN ARKANSAS

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Aerial applications of Bti and the monomolecular film, Aerosurf<sup>R</sup> 66E, were applied against indigenous populations of Anopheles quadrimaculatus Say with a Becomist<sup>R</sup> unit. Percentage control 24 h posttreatment at 1 liter/ha was 98% with the former while the latter compound provided slightly less control. Teknar<sup>R</sup> was also trickled into irrigation water. This economic method of treatment should function well in fields with straight levees which have a reasonably fast water flow. Sampling techniques for monitoring native riceland mosquito larvae were investigated in conjunction with the above experiments. These sampling studies revealed a critical need for an improved method.

**R15.4.****1**

## SIMULIIDAE OF THE THYOLO HIGHLANDS OF MALAWI

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The small isolated focus of onchocerciasis on the Thyolo Highlands of Malawi is possibly the most southernly extension of the disease in Africa. The area is separated from the nearest focus in Tanzania by about 800 km. Three possible vectors have been reported from Thyolo, Simulium damnosum s.l., S. woodi and S. nyasalandicum.

The results of a survey to try to define the vector species and its distribution showed that twelve species of Simulium were breeding in the area, but S. damnosum was the only vector species found. Two flies were found carrying infective larvae similar to Onchocerca volvulus.

The distribution of anthropophilic S. damnosum s.l. and the <sup>P</sup>arent absence of the S. neavei group species will be discussed.

**R15.4.** THE ECOLOGY OF BLACK FLIES (DIPTERA: SIMULIIDAE) IN THE DESERT  
**2** STREAMLETS OF SHITHATHA OASIS, KERBALA, IRAQ

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The ecology of Simuliidae was studied in the desert streamlets of Shithatha Oasis, Kerbala, Iraq for twelve months in 1982-1983. The larval, pupal and egg densities were estimated bimonthly at 3 sampling sites together with the ecological variables: water temperature, air temperature, water velocity, water depth and water discharge. Collections of associated organisms were also made. Results revealed that the dominating species was Simulium (Wilhelmia) pseudequinum Séguy. Larvae of this species were present throughout the year attached to blades of aquatic plants and bottom rocks. The temperature of water was almost stable throughout the year ranging from 21° and 28° C. The associated organisms belong to the families: Chironomidae, Ephydriidae, Hydropsychidae, Hydroptilidae and Caenidae.

**R15.4.** CIRCADIAN FLIGHT ACTIVITY OF BLACK-FLIES (DIPTERA: SIMULIIDAE)  
**3** COLLECTED USING A VEHICLE-MOUNTED NET IN CENTRAL NIGERIA.

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A vehicle-mounted net was used to study the flight activity of five species of black-flies, including Simulium squamosum, in a guinea savanna region during the dry season.

All the species showed a major peak of flight activity just after sunset and a smaller peak at sunrise, although there were differences between the species and between the males and females. The female's rhythm depended upon their physiological state. Blood-fed flies (which in S.squamosum made up 11 % of the females) and the gravid females were only active in the evening, while the blood-thirsty females had a greater level of activity throughout the day. Parous females of S.squamosum were most abundant in the morning, while nullipars were most active in the evening. These differences in the rhythms are discussed with respect to the meteorological conditions.



**R15.4.** THE EFFECTS OF NUTRITION AND PARASITISM ON THE FECUNDITY OF  
**4** LABORATORY REARED BLACKFLIES (DIPTERA, SIMULIIDAE).

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Simulium ornatum sl. adults were reared from field collected larvae and pupae in the laboratory. The effects of the presence or absence of a sugar diet as well as experimental infections of Onchocerca lienalis, a filarial nematode, on the fecundity of blood fed females were studied. A significant correlation with a logarithmic fit, was found between egg numbers and numbers of developing Onchocerca larvae. In addition, the absence of sugar from the diet also markedly reduced the fecundity of uninfected flies but the already low level of eggs in infected flies was not greatly reduced further. Furthermore, the absence of a blood meal was found to significantly reduce the proportion of microfilariae able to develop in the thoracic musculature.

It is clear therefore, that fecundity is not purely determined by the blood meal size or the age of the fly. Other factors, being interrelated, also play a role in determining the number of eggs. This experimental system is a natural vector/parasite relationship and may prove useful as a model to study the human onchocerciasis vector biology of systems like that of S. damnosum sl./O. volvulus.

**R15.4.** STUDIES ON THE ECOLOGY AND DISTRIBUTION OF THE BEFFA FORM  
**5** OF SIMULIUM SOUBRENSE/S. SANCTIPAULI

R. A. CHEKE

Tropical Development and Research Institute, London

The recently described Beffa form of *Simulium soubrense*/S. *sanctipauli* has been shown to be a vector of onchocerciasis. Aspects of its ecology, distribution and behaviour were studied in Togo and Benin. Identifications, based on the morphology of females coming to bite man and on adults of both sexes obtained from field collections of pupae, showed that the form was widely distributed in southern areas of the two countries. The form's range expands considerably during rainy seasons, when it can become the most abundant member of the *S. damnosum* species complex in some areas. The form also exhibits regional variation in morphological characters such as wing tuft colour.

**R15.4.**  
**6** FOLLOWING MOVEMENTS OF RESISTANT POPULATIONS OF SIMULIUM SOUBRENSE/SANCTIPAULI (DIPTERA: SIMULIDAE) BY MEANS OF CHROMOSOME INVERSIONS

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In West Africa, the species group Simulium soubrense/sanctipauli of the S. damnosum complex can be divided into at least 3 sub groups on the basis of polymorphic chromosome inversions.

In 1980-1981, resistance to organophosphate insecticides occurred in the sub-group which then occupied essentially the area of Ivory Coast. This resistance was correlated with a small inversion on chromosome II.

Since then, resistance has spread eastward into southern Ghana. Resistant larvae can be identified by the possession of this inversion, which shows that resistance is spreading by West to East movement of the population.

**R15.4.**  
**7** VERIFICATION OF MORPHOLOGICAL CHARACTERS FOR THE SEPARATION OF SIMULIUM SANCTIPAULI AND S. YAHENSE BY ENZYME ELECTROPHORESIS

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*Simulium sanctipauli* and *S. yahense* are widely distributed in the rainforest zone of Liberia and have been incriminated as the main vectors of *Onchocerca volvulus* in this country. An accurate identification of the females of these two species which breed in different types of watercourses but are morphologically similar is essential for a proper study of their epidemiological importance and the planning of control measures. Various external characters were scrutinized for their diagnostic value by the comparison of identifications using these characters and those based on enzyme electrophoresis (phosphoglucomutase, trehalase). Results demonstrated that females of the two species of the *S. damnosum* complex can be separated reliably by the use of external morphological characters. The occasional finding in the same fly of phosphoglucomutase variants typical for each species indicated the possible occurrence of natural hybridization between *S. sanctipauli* and *S. yahense*.

**R15.4.** THE RELATIVE IMPORTANCE OF DIFFERENT MEMBERS OF THE *SIMULIUM*  
**8** DAMNOSUM SPECIES COMPLEX AS VECTORS OF ONCHOCERCIASIS IN  
TOGO AND BENIN

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<sup>2</sup>Tropical Development and Research Institute, London

In Togo and Benin the *Simulium damnosum* complex is represented by *S. damnosum* s.str., *S. sirbanum*, *S. squamosum* and *S. soubrense/S. sanctipauli*. These species differ in their breeding sites and migratory behaviour. All were shown to harbour filarial larvae indistinguishable from those of *Onchocerca volvulus*, but the percentages infected and the mean parasite loads in infected flies differed. The highest infection rates were found in *S. damnosum/S. sirbanum* populations but the highest mean numbers of larvae per infected fly were recorded in the Beffa form of *S. soubrense/S. sanctipauli* which is, therefore, probably an important vector of *Onchocerca volvulus*.

**R15.4.** THE ONCHOCERCIASIS CONTROL PROGRAMME OF THE WORLD HEALTH  
**9** ORGANIZATION IN WEST AFRICA

GRUNEWALD, J.<sup>1</sup>, PHILIPPON, B.<sup>2</sup>

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Onchocerciasis, or river blindness, is a parasitic disease caused by a nematode worm *Onchocerca volvulus*. It is transmitted by female Simuliidae and affects more than 20 mill. people in tropical Africa, the Yemen and parts of Central and South America. Besides important clinical manifestations the most serious consequences of the disease are eye lesions leading to blindness. The savanna area of the Volta River Basin in West Africa is one of the worst endemic onchocerciasis zones of the world. In this area, which includes parts of 7 West African countries the WHO launched the Onchocerciasis Control Programme in 1974 scheduled to last 20 years. In the absence of an acceptable drug for mass chemotherapy, control of the insect vectors, species of the *Simulium damnosum* complex, by periodical applications of insecticides to their breeding sites in rivers offered the only means for interrupting the transmission of the disease. Because of the inaccessibility by land of many breeding sites the only feasible method of applying the insecticides was from the air by helicopters and light planes. By the end of 1983 it was believed that transmission had been interrupted in more than 80% of the total of 764 000 km<sup>2</sup> covered by the Programme. In the remaining 20% of the area transmission is not fully interrupted yet due to resistance problems of some vector populations against the insecticide and to the reinvasion of blackflies from untreated zones outside the Programme area.

R15.4.  
10

THE MICROBIAL CONTROL OF BLACK FLIES (DIPTERA : SIMULIIDAE)

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Black flies have a foremost medical and veterinary importance around the world, and environmentally safe larvicides for their control are now greatly needed. After an extensive screening of black fly entomopathogens as potential biological agents, we selected *Bacillus thuringiensis* serovar. *israelensis* for experiments in the laboratory and in the field. We used an experimental preparation provided by Sandoz Inc., and tested in the laboratory its toxicity for different black fly species in relation to temperature, exposure time, pH, and concentration. In a field trial where all black fly larvae were killed, we examined the impact on other stream insects, especially Diptera. The objective of these experiments, and other studies on the feeding behavior of larvae and environmental parameters, is the optimization of large scale control programmes. Parallel studies are currently made on the identity and occurrence of microsporidia infecting natural populations of black flies in the Trois-Rivières (Québec, Canada) area.

R15.5.  
1 BLOOD-SUCKING ACTIVITY IN PALAEARCTIC SYMPHOROMYIA  
(DIPTERA, RHAGIONIDAE)

MILAN CHVÁLA

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Biting of man by Symphoromyia snipe-flies is a common habit in North American species but it has not been known in the Palaearctic. The first case of blood-sucking by Symphoromyia has recently been found in Soviet Central Asia (Uzbekistan and Tadzhikistan). Females of the Asiatic S. spitzeri CHV. actively suck blood on man in mountain biotopes. The distribution of the species is sympatric with the related Euroasiatic S. crassicornis PANZ. Females of S. crassicornis are obviously haematophagous, they are able to feed on blood, but are unable to suck it actively. Besides distinctive morphological characters both species also differ in the structure of mouthparts. Females of the non-biting S. crassicornis have vestigial non-functional mandibles, whereas females of S. spitzeri have fully developed mouthparts with large functional mandibles.

15

R15.5.

2

A.E.TERTERIAN

INSTITUTE OF ZOOLOGY ARM SSR 7, P.Sevak str. Yerevan USSR

The morphology of the male terminalia and sclerites of the scutum of 13 palearctic genera of horseflies was particularly investigated by us (Terterian, 1978, 1981).

We attach great importance to the structure of the tarsus of forelegs and partly to its chetotaxy. In primitive groups of horseflies (Pangoniini, Chrysopsini, Diachlorini) the same form of the 5th segment of the tarsus of forelegs is observed.

The evolution of the life in two "adaptive zones" - in water and in soil environments.

R15.5.

3

A PRELIMINARY STUDY OF THE BIONOMICS OF TABANUS IMPORTUNUS WIED. IN THE COASTAL SAVANNAHS OF FRENCH GUIANA ( TABANIDAE : DIPTERA )

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Tabanus importunus Wied., a major cattle pest in French Guiana, is the most abundant diurnal tabanid species in the coastal savannahs. The seasonal biting peak occurs during the late dry season since mid-october till early december. The daily biting peaks take place in mid-morning and late afternoon. The flies can inhibit totally the diurnal grazing. The density of the flies is higher on the edge of wooded areas than in the pastures. The female is anautogenous. Egg-masses were found on stems of grasses and shrubs (mainly Cyperaceae) above the dry sandy soil of the savannah. Mature larvae were recovered from the soil. The eggs are parasitized by Microhymenoptera. The abundance of the horse guard wasps Stictia and Rubrica (Sphecidae) is too low for fly control in november. Permethrin sprays are ineffective. Deltamethrin foggings kill immediately some flies but their effect lasts only few hours.

**R15.5. 4** TABANID BIOLOGY AND BEHAVIOR: EFFECTS ON DISEASE TRANSMISSION AND CONTROL.

L. D. FOIL AND C. J. ISSEL Departments of Entomology and Veterinary Science, L.S.U., Baton Rouge, LA. 70803, USA

Data are presented to explain epidemiologic patterns of diseases mechanically transmitted by tabanids. Tabanid transmission of equine infectious anemia (EIA), a horse disease of worldwide importance, is the example used. Status of the host, vector and pathogen are shown to be important in field transmission of EIA. Among the factors discussed are the pathogen titer within the vertebrate, the environmental stability of the pathogen, the proximity of infected and susceptible animals, the abundance and composition of the insect vectors that are present, and the feeding persistence and host-seeking behavior of the insect vectors that are present. Studies concerning tabanid control are also presented. Techniques used to determine the impact of different control methods upon tabanid populations is presented. The efficacy of ultra low volume insecticide applications and permanent trapping methods for tabanid control will be discussed.

**R15.5. 5** THE EFFECT OF ISOMETAMIDIUM CHLORIDE ON TRYPANOSOMA VIVAX OCCURRING WITHIN THE INSECT VECTOR (GLOSSINA).

DR. W. E. AGU  
NIGERIAN INSTITUTE FOR TRYPANOSOMIASIS RESEARCH, VOM, P/STATE NIGERIA.

The effect of chemoprophylaxis on developing and mature Trypanosoma vivax in Glossina tachinoides and G. palpalis was evaluated. Newly emerged G. tachinoides and G. palpalis were infected with T. vivax by allowing them to feed on parasitaemic animals. One group of the infected flies was fed on animals treated 1 day previously with isometamidium (1mg/kg.) after which the surviving flies were dissected and examined for trypanosomes; the other group was fed on untreated animals. Out of a total number of 123 flies which fed on treated animals, none were found to be infected, while 51 out of 127 flies which fed on untreated animals were infected. It was concluded that prophylactic treatment of animals with isometamidium would eliminate T. vivax infections from the insect vector. The potential significance of this finding to the control of trypanosomiasis in the field was discussed.

**R15.5.** COMPARATIVE STUDY OF THE SUSCEPTIBILITY TO INFECTION WITH  
**6** TRYPANOSOMA SIMIAE OF GLOSSINA MORSITANS AND G. TACHINOIDES.

DR. W. E. AGU

NIGERIAN INSTITUTE FOR TRYPANOSOMIASIS RESEARCH, VOM, P/STATE

Although the distribution of different Glossina species in Nigeria is well known, evidence of differences in susceptibility to trypanosome infections between the species is scanty in the Country. The objective of this study was to compare the susceptibility to infection with Trypanosoma simiae of Glossina morsitans and G. tachinoides. A total of 592 G. tachinoides and 348 G. morsitans were used in trying to transmit T. simiae to pigs. G. morsitans were very good at transmitting T. simiae infection to pigs while G. tachinoides were very poor. The epidemiological importance of the results is discussed.

**R15.5.** DETERMINING THE AGE OF ADULTS OF STOMOXYS CALCITRANS (L.)  
**7** AND GLOSSINA MORSITANS MORSITANS (L.)

MAIL, T.S. and LEHANE, M.J.

School of Animal Biology, U.C.N.W., Bangor, Gwynedd LL57 2UW, U.K.

Investigations have shown that measurement of fluorescent eye pigments, the pteridines, provides a rapid and accurate means of determining the age of adults of the stablefly, Stomoxys calcitrans (L.) and the tsetse fly, Glossina morsitans morsitans (L.). A review is presented on this age-determining technique, including a discussion of factors likely to affect its accuracy under field conditions.

**R15.6.** STUDIES ON PROBABLE VECTORS OF ZOONOTIC CUTANEOUS  
**1** LEISHMANIASIS IN BALUCHISTAN, IRAN

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School of Public Health, Teheran University, P.B. 1310, Teheran, Iran

Zoonotic cutaneous leishmaniasis has been endemic in Baluchistan but with low incidence in a very limited area. Our previous studies on sandflies has shown the presence of: Ph. papatasi, Ph. salehi, Ph. bergeroti, Ph. sergenti, Ph. alexandri, Ph. caucasicus, Ph. kazeruni, Ph. eleanorea, Ph. chinensis, Ph. mesghali, S. sintoni, S. dentata, S. mervynae, S. antennata, S. baghdadis, S. africana, S. squamipleuris, S. powlowskyi, S. clydei, S. tiberiadis, S. christophersi & S. iranicus in southeastern of Iran.

In recent years the incidence of the disease is being considerably increased & we started an investigation of the disease in 1983. Our studies up to present showed that: a) Settlement in newly developing area had important effect on sandfly-man relationship & ultimately has infected the residents. b) Ph. papatasi & Ph. salehi were active even in December. c) Ph. papatasi is the main vector.

**R15.6.** FORENSIC ENTOMOLOGY AND THE MAGGOT CLOCK  
**2**

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Forensic entomology involves the use of insects in legal proceedings. Using insects to "tell the time" of death of a homicide victim has been reported since the 19th century. Time of death is used in determining the innocence or guilt of the accused as well as in inheritance cases and at present there is no reliable way to estimate it after 24 hours. With increasing use of maggots to estimate the time of death, there is a need for entomologists to establish the validity and limitations of this method. Our laboratory and field studies have shown the effects of temperature, species of maggot, body size of host, whether the host is wounded or intact, and source of food on development time of maggots. We have concluded that the "maggot clock" when properly used, is valid for estimating a minimum time since a body was deposited in a field within the 1-14 day time period and during certain months.



## R15.6. HOST DEPENDENCY OF RAT FLEAS

3

R.S.PRASAD

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Fleas show more intimate association with their hosts than other haematophagous insects like mosquitoes. But rat fleas Xenopsylla cheopis and X.astia denied of the contact with a live host and fed artificially through rat membrane on whole blood of white rat or artificial diet would mate and lay viable eggs, though oocyte maturation in these cases was delayed and fecundity rates reduced considerably, compared to natural condition. Reproduction of these fleas is not under the influence of mammalian hormones. Experimental evidences support the suggestion that these fleas must have constant contact with the host for the purpose of having small but frequent blood meals to sustain continuous egg laying, unlike mosquitoes which lay one batch of eggs on one blood meal. The factors which bring about this limitation are those that decide the host dependency of these fleas. Based on experimental evidences a hypothesis is formulated that the limit of extensibility of the abdomen and the low protein storage capacity of the haemolymph are the factors which force these fleas to resort to small but frequent blood meals which in turn dictates the closer association of these fleas to their hosts.

## R15.6. THE UP-TO-DATE COCKROACH CONTROL SYSTEM

4

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During the recent 10 years cockroaches have considerably increased in the big cities of the World. This applies to Budapest where infestations occur primarily in the flats of housing estates of panel constructions. The cockroach infestation of this flats are 32-37 %.

To dissolve this problem we have work out a new control system of housing estates of panel constructions, which we have finished more than 50.000 flats from 1978 till the end of 1983. We take care of the continual maintenance of the cockroach-free state.

We review the organization, methodology and technology of this program. The complex organisational and methodical experiences suitable for the organised cockroach control of whole Budapest, or in any large towns.

**R15.6.** THE INFLUENCE OF BLASTOCRITHIDIA TRIATOMAE (TRYPANOSOMATI-  
**5** DAE) ON REPRODUCTION OF TRIATOMA INFESTANS(REDUVIIDAE)

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Institut für Biologie I (Zoologie), Universität Freiburg, FRG

In previous studies we observed pathogenic effects of the monoxe-nous flagellate Blastocrithidia triatomae on larvae of different reduviid bugs, the vectors of Chagas' disease. In order to study the rate of reproduction infected adults of Triatoma infestans were reared in groups or pairs (only one sex infected). Eggs of these bugs and of uninfected controls were counted daily and col-lected and weighed twice a week. Developmental time of the eggs, hatching rate and weight of the progeny was determined. Aging of infected and uninfected females resulted in increased periods when no eggs were laid and a decrease in egg-weight. In infected groups or pairs of bugs the number of laid eggs/day and the egg-weight was always reduced as compared to the controls. In-fected females laid fewer eggs/day than females of infected males (but with a similar weight) and died earlier than infected males. The hatching rate of eggs from infected adults was reduced, possi-bly as a result of the low egg-weight; the difference in weight of the progeny was not statistically significant. Because of the effects on larval and adult bugs B. triatomae may be used for a biological control of vectors of Chagas' disease. Supported by the Deutsche Forschungsgemeinschaft

**R15.6.** INFLUENCE OF THE FIBRE DIAMETER ON THE SURVIVAL OF BOVICOLA SPECIES  
**6** REARED OFF THE HOST

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Department of Parasitology. Phaculty of Pharmacy. University of Granada. Granada (Spain).

Hair diameter of the host seems to have influence on the ovoposition and mo-vement of the Mallophaga. On the other hand, the grand specificity of host that they have, could be conditioned form the necessity of determinate fi-bre diameter. In this work the "in vitro" survival (in days) of Bovicola spe-cies using as inert base host hair and artificial fibres of three different diameters has been studied. Parasites were reared to 35<sup>+</sup>1.5°C y 75<sup>+</sup>5% de R.H. using skin scraps as food.

	<u>Hair (d=99 u)</u>	<u>F1 (d=284 u)</u>	<u>F2 (d=235 u)</u>	<u>F3 (d=117 u)</u>
LARVES	They moult to adult	2.37	1.50	2.50
FEMALES	6.13	2.43	2.23	2.55
MALES	1.09	0.90	1.08	1.35

(Each date is mean of 40 values).

Watching these dates we can say: a) Sex seems to have influence on the adap-tation to the fibre diameter. b) fibre diameter seems to conditionate the survival culture.

**R15.6.** APPLICATION OF ELECTROPHORETIC TECHNIQUES TO DIFFERENTIATE SPECIES  
**7** OF GENUS BOVICOLA (MALLOPHAGA)

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Department of Parasitology. Faculty of Pharmacy. University of Granada.  
Granada (Spain).

Two species of the genus Bovicola: B.caprae Gurlt 1843 and B.limbata Gervais 1844 are usually mixed on the same host, Capra hircus L. In 1936 Werneck was the first who described and differentiated these two species; these differences were based on external morphology: genital apparatus of the male, chetotaxy in the vulvar zone of females, etc. Our recent studies about taxonomy of these species have induced us to the conclusion of that the separation based on morphologic characteristics, specially when they are mixed on the same host specimen and above all in the case of females in which the specific differences are much less evident is sometimes difficult. In vitro colonization of both species doesn't have been useful to obtain specimens with very different morphologic characteristics, either.

In the present study we have introduced and applied electrophoretic techniques in polyacrylamide gels in order to reinforce and confirm the dates obtained with the optic microscope which are available for the specific differentiation.

**R15.6.** Study on the occurrence and high incidences of scorpions  
**8** in Khuzestan, IRAN

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Regular inspections made in refugees camps and clinics of over-crowded towns of Khuzestan Province since 1980, marking the beginning of border conflict between Iran and Iraq. It revealed an increasing incidences of scorpion-sting, with frequent mortality among childrens as well as adults. In June 1983 (e.g.) a total of 108 cases of inflicted patients were treated in only one of <sup>the</sup> several hospitals in Ahwaz. References to the clinics of Dezful and Ramhormoz were as high as to that of Ahwaz, and they were estimated more than many thousands of cases in 1983 alone.

More than 8 species of scorpions were found in the area and several nesting places were studied. Distribution, behavior, preventive and control measures, treatment, and the causes of mortalities are discussed.

R15.6.  
9 "ECOLOGICAL RELATIONS OF PHILORNIS LARVAE (DIPTERA, MUSCIDAE) WITH BIRDS"

MÁRCIA SOUTO COURI  
MUSEU NACIONAL, QUINTA DA BOA VISTA - RJ, BRASIL 20.942

The species of Philornis Meinert, 1890 are bionomically very interesting, especially in their early stages. The larvae live either freely in small birds nests (coprophagous or semi-hematophagous habits) or intradermically (hematophagous habits). The coprophagous larvae are seemingly the more primitive, and the hematophagous ones, the more complex. The majority of muscids larvae is found in decaying organic matter and a larva adapted to a intradermical life, seems to be the more evolved stage.

Oviposition is done in the nest or directly on the skin of the nestlings. The number of larvae on nestlings varies in different species. Smith (1968) states that more than seven larvae per nestling is fatal. Cases of two nestlings of Pitangus sulphuratus (Tyrannidae) surviving respectively with fourty one and thirty two larvae were however recorded.

Dodge (1968) mentions an unusual case of a Philornis species that were collected in wasp nest, suggesting the probable association of the wasp with the bird nest. Smith (1968) also mentions a bird species that build their nests in close neighbourhood with the wasps and bees, which, for some reason deter Philornis flies. These two cases can be explained with the wasps predator habit. Many wasps arrest adults of Philornis (and other Diptera), probably to feed their larvae.

S15.1.  
1 ERADICATION OF HYPODERMOSIS BY INTEGRATED PEST MANAGEMENT (IPM)  
WITH STERILE INSECT RELEASES

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A conceptual model was developed to assess the effect of natural mortality factors on the persistence of Hypoderma populations and their recovery from insecticidal control. A significantly high, density-dependent mortality in the first-instar larvae was a key factor that stabilized the grub populations, limiting excessive increase while ensuring survival at low levels. Systemic insecticides imposed additional mortality at this larval stage but the population was adapted to minimize the impact through the density-dependent nature of the mortality. Characteristics of pupal development and adult behavior also acted to perpetuate reduced populations by concentrating the reproductive activity of the flies. IPM combining sterile warble fly releases with organized use of systemic insecticides was proposed to achieve significant control or eradication. The concept was validated on a large ranch on which the H. lineatum population was eliminated by sterile fly releases while H. bovis persisted despite continued use of insecticides alone.

A pilot project was organized as a joint Agriculture Canada-USDA effort with the objectives of regional elimination of warble grubs in a defined Alberta-Montana land area and evaluation of the economic benefits of the IPM to the cattle industry. The project has now commenced with surveys of the grub population levels in the two areas, establishment of procedures for the enlarged scope, and conducting the initial IPM operations.

S15.1.  
2

## MANAGEMENT OF CATTLE WARBLER, HYPODERMA SP., IN THE UNITED STATES

SIDNEY E. KUNZ

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Control of Hypoderma warbles in the United States has been left to the individual cattle producers with no legislated or required treatment procedures. Systemic insecticides where used have been effective, but the lack of economic data on costs resulting from warble damage has made it difficult to obtain large-scale control efforts. Recently a joint Canadian-United States study was initiated to evaluate integrated pest management (IPM) of cattle grubs, Hypoderma lineatum (L.) and H. bovis (DeVillers). The project objectives of the 5-year study are 1) to determine whether the use of systemic insecticides combined with release of sterile heel flies will eliminate cattle grubs from a defined area; 2) to determine if such eradication is feasible in an area containing both species; 3) to evaluate the economic benefit of cattle grub IPM to the cattle industry. More than 22,000 head of cattle were treated with 20% fenthion Spotton® the first year with a 99% reduction of grubs when compared with untreated cattle. Grubs surviving treatments were found in 9.2% of the cattle with a mean of 1.4 grubs/animal. About 27,000 animals were treated the second year. H. lineatum and H. bovis 3rd-instar larvae were collected, reared to adults, sterilized, and released onto the treated area in 1983 and 1984.

S15.1.  
3

## PROGRESS OF THE WARBLE FLY ERADICATION SCHEME IN BRITAIN

D W TARRY

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The UK warble fly eradication scheme was initiated in 1978, when the 'Warble Fly Order' was introduced requiring the owner of any animal showing warble grubs in the back in the period March 13 to July 31 to treat it with an approved dressing. Voluntary autumn dressing was also encouraged. Following marked success a further Order in 1981 required treatment of the entire affected herd, and provided for compulsory re-treatment in the autumn. From March 15 1982, the appearance of warble fly larvae in cattle became notifiable. The proportion of affected animals in the national herd fell rapidly, from over 20% in 1978 to less than 1.0% in four seasons, and to 0.4% in 1983. "Pockets" of greater warble fly activity were apparent in 1983, and are being dealt with by 'infected area' legislation. Bionomics of these isolated breeding populations will be discussed.

# 515.1. 4 PRESENT STATE OF HYPODERMA CONTROL IN CZECHOSLOVAKIA

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Hypodermatosis of cattle was widespread in Czechoslovakia in all pasture regions where 80-100% of young cattle and 30% of all cattle statewide were infested after World War II. Losses caused by hypodermatosis amounted to 100 million Czechoslovak crowns annually. Control measures by means of effective Czechoslovak preparations based on organophosphate trichlorfon (Hypocid and Arpalit Spray) were initiated in 1969. Young cattle were treated using pour-on method in autumn and the remaining larvae were killed in spring. By 1972 hypodermatosis was thus eliminated in Bohemia and Moravia. In Slovakia, where it was much more widespread, control measures were started in 1971. By 1977 the intensity of infestation in heifers decreased from 80 to 20%, in all cattle from 30 to 12%, in 1979 it dropped to 6%, in 1980 to less than 2%, in 1981-82 to 0.12-0.15%. In 1983 the incidence increased to 2% due to a higher ability of low warble fly populations to build up, facilitated by a lesser attention paid to control. At present the percentage of cattle infestation in Czechoslovakia has been reduced to less than 1%. Control measures used have been based on data obtained in the research of population ecology of warble flies and a complete eradication of hypodermatosis in this country is anticipated.

# 515.1. 5 BOVINE HYPODERMOSIS CONTROL IN FRANCE

Chantal BOULARD

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The first national program of hypodermosis control started in October 1978 in France. Taking into account the great variety of climatic, geographic situations and bovine management practice a departmental scheme was drawn up to be adapted to local situation and the national co-ordination was committed to the National bovine Sanitary Committee. The control was performed by a unic systemic autumn treatment on heifers and repeated topical spring treatments on dairy cows. After a five years program, limited results were obtained. The limiting factors are manifold related to a specific French context of legislation and farmers cooperation and are relevant also to the hypodermosis survey technics. This first step in developing a national program of hypodermosis control stresses the main problems to be improved in the future national scheme.

## **S15.1.** EVOLUTION OF HYPODERMOSIS IN AUSTRIA **6**

E.KUTZER

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In Austria the hypodermosis in cattle does not play a great economic role at present, due to a specific treatment campaign. The complete eradication of hypodermosis is above all a financial and an organizational problem. So the Tyrol and Salzburg for example have become free of warbles, whereas in other provinces the infestation has been greatly reduced; but on the whole we cannot speak of an eradication. It is significant that both in Lower Austria and Upper Austria though the same scheme of treatment has been in operation since 1982 the number of positive cases has slightly increased. The degree of infestation can generally be considered low. Exact details about the extent of damage which is being caused by the warbles at present are not available. The economic loss of today, however, might be put at less than 5 million Austrian Shilling (In 1965 the economic loss was 100 million A.S.). Thus follows that the success of treatment can be regarded as satisfactory.

## **S15.1.** THE BOVINE IMMUNE RESPONSE TO HYPODERMA LINEATUM **7**

JOHN H. PRUETT

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This presentation includes the results of studies on the bovine immune response to Hypoderma lineatum. These studies were designed to identify host protective immune responses to H. lineatum. Aspects of the kinetics of humoral antibody development, in vitro lymphocyte responses, in vivo skin reactions to fractionated H. lineatum proteins, and our ongoing efforts to improve upon the serological diagnosis of hypodermosis are discussed. Antigenicity of soluble H. lineatum proteins in the bovine system and their comparison with crossreacting proteins of the rodent bot, Cuterebra fontinella, are included. The results of vaccination attempts, using as immunogens crude H. lineatum proteins, purified H. lineatum proteins, and C. fontinella 2nd-instar proteins, describe the use of vaccination as a potential means of control.

## S15.1. HYPODERMOSIS CONTROL PROJECT IN TURKEY

8

AHMET KALKAN

Head of Veterinary Institutes, General Directorate of Veterinary Services,  
Ministry of Agriculture, Forestry and Rural Affairs, Ankara, Turkey

A national hypodermosis project aimed to eradicate the warble fly in Turkish cattle is presented. This 2-phase project has operated since 1982, the 1st phase aimed to determine infection rate and incidences of the Hypoderma spp, and the 2nd phase, a control program, schemed to treat 16 million cattle per year for at least 3 yrs, starts in 1985. In 1982-83 studies, carried out in 30 localities representative of 7 major geographical regions and 21 subregions of Turkey, it was observed that hypodermosis occurred in 4-character 2-pattern infections, either a single infection of H. bovis or mix infection of H. bovis and H. lineatum. Mix infections were detected, varying from area to area, in regions with prevalences of H. bovis higher than H. lineatum, or H. bovis and H. lineatum almost distributed equally, or of H. lineatum higher than H. bovis in 30 localities. In 1983-84, effects of altitude, humidity, and vegetation on Hypoderma spp. and their activities were investigated; efficacy tests of certain drugs were carried out in 8 representative localities and summarized.

## S15.2. ASPECTS OF THE REPRODUCTIVE BIOLOGY OF SOME CATTLE-VISITING MUSCIDAE (DIPTERA) IN NORTH-EAST ENGLAND.

1

BALL, S. G.                      PORT, G. R.                      LUFF, M. L.

Dept. of Agricultural Biology, The University, Newcastle upon Tyne, U.K.

During studies of the flies that visit farm animals in north-east England, samples of Muscids were obtained on a regular basis, both from grazing animals (mainly cattle) and from Manitoba traps.

Female flies were examined to determine their size (wing length), degree of wing damage (correlated with age), whether or not they had mated, whether their gut contained blood, the stage they had reached in the ovarian cycle and the number of eggs present.

This data was used to assess the timing of mating, the stage at which blood meals were taken and the potential fecundity of the more numerous species, especially Hydrotaea irritans (Fal.) and Morellia simplex (Loew). A relationship between the size of an individual and the number of eggs it carried was found in several species.



**S15.2.** DEPOSITION OF LARVAE BY THE LARVIPAROUS NOSE BOT FLIES, CEPHENEMYIA  
**2** APICATA AND C. JELLISONI (DIPTERA: OESTRINAE).

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The mechanism by which these flies expel larvae and deposit or eject them onto the nose of the vertebrate host was studied by analyzing their internal anatomy and by observing the ejection of larvae by electrostimulated females under experimental laboratory conditions. Electrostimulated C. apicata, everted the larvipositor and larvae simultaneously were expelled in a drop of fluid formed at the end of the larvipositor. The expelled drops had a sticky membranous surface and contained about 20 larvae. Larvae of C. jellisoni were sprayed forcefully an average of 12.6 cm in many discrete droplets containing from 1 to 5 larvae. In both species larvae appear to enter the larvipositor when a 3-flap valve at the junction of the uterus is in the relaxed, open position. The valve closes as the 3 flaps overlap when the larvipositor is everted, and larvae are forced out of the stretched larvipositor in an accompanying drop of uterine fluid.

**S15.2.** INCIDENCE AND SEASONAL VARIATIONS OF GASTEROPHILUS SPP: LARVAE  
**3** (DIPTERA: GASTEROPHILIDAE) IN THE STOMACH OF DONKEYS IN EGYPT.

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The stomach of 118 donkeys were examined at postmortem during the period from March 1982 to February 1983 for Gasterophilus spp larvae\*. G. intestinalis larvae\* clustered in groups near the boundary of the glandular and nonglandular epithelium of the stomach. The larvae\* of G. intestinalis infest 98.3% of donkeys with highest number in July and lowest in October. G. nasalis larvae\* were attached mainly near the pylorus and first part of the duodenum. Its larvae infest 85% of donkeys with highest incidence in December and lowest in October. The seasonal variations of each of the 2nd and 3rd stage larvae was determined for each species. The ratio of G. intestinalis to G. nasalis larvae\* was 71% to 29%. The size of infestation showed that the percentage of donkeys infested with 1-100, 101-200 and 201-300 larvae\* were 72.0, 18.6 and 4.3% for G. intestinalis and 76.3, 8.5 and 0.8% for G. nasalis

\* Second and third stage larvae

**S15.2.** HOST FINDING AND FEEDING IN HYDROTAEA IRRITANS (DIPTERA, MUSCIDAE)  
**4** THE ROLE OF CHEMICAL SENSES

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*H. irritans* is commonly considered to be the primary vector for the bacteria causing summer mastitis in cattle. A behavioural physiology approach was used to investigate potential host odours that may be used by the fly in finding its host and to determine which substrates or sites on the host are utilized in feeding. Attractant odours include CO<sub>2</sub> and butyric, propionic and acetic acids. The last 3 of these are also produced by the bacteria causing summer mastitis. Of the various substances offered as feeding substrates such as milk, slaver, mastitis secretion and blood only the last two of these produced significant increases in feeding duration in comparison to controls with distilled water.

**S15.2.** AIRCRAFT DISINSECTION: AN INTERNATIONAL CONCERN FOR THE PROTECTION OF  
**5** MAN AND AGRICULTURE

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The advent of the Jet-Age introduced a new concern to mankind and agriculture, the chance for accidental transportation of hitch-hiking arthropod pests and/or vectors of diseases transcontinentally and transoceanically in a few hours. Although methods for aircraft disinsection were developed in the 1950's for use on commercial domestic and international flights, the chance introduction of medically and agronomically important arthropods has increased with the increase in volume and number of destinations for commercial flights. Within the past 2 years 2 species of Diptera, previously unrecorded for North America that are ectoparasitic on livestock and carnivores, have been collected in New Jersey and North Carolina. Currently, d-phenothrin and resmethrin as 2% aerosols have been registered for disinsecting passenger compartments on commercial aircraft by flight attendants. There are several new insecticides which would be suitable for use in passenger compartments and are effective against a wide range of insect pest species. From our evaluation of insecticides tested with simulated aircraft, fenvalerate and cypermethrin are among the more effective compounds, controlling the test species with less than a 3 minute exposures to 2% aerosols applied at 8.5 mg ai/m<sup>3</sup>.

## S15.2. BACTERIAL PATHOGENS CARRIED BY CATTLE FLIES

6

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Various Muscidae have been implicated in the spread of bovine keratoconjunctivitis and 'summer mastitis'. We have sampled cattle flies from dairy heifers at pasture in 1982, 1983 and 1984 for bacteriological examination. Some 3-4% of Hydrotaea irritans females carry the mastitis pathogens, but only in August and September. Infected flies can be found around herds even in the absence of clinical cases. The coincidence of more than one mastitis pathogen in most infected flies suggests that the flies may be involved in the spread of the disease but probably are not involved in the initial infection. We have obtained little evidence of fly transmission of pathogens in keratoconjunctivitis.

## S15.2. Investigations of fly populations on cattle and the protection obtained with synthetic pyrethroid impregnated ear tags.

7

J STUART LIDDEL

SHELL CHEMICALS UK LTD ANIMAL HEALTH DEVELOPMENT St MARY'S STREET ELY CAMBS

The distribution of fly species (Diptera) on beef cattle while at pasture was investigated weekly during the fly season May to September over four years on a farm in southern England.

Two similar groups of cattle were observed each year, one untreated control group and a second group tagged in one ear with a cypermethrin insecticide - impregnated ear tag. In the fourth year the protection given by a fenvalerate tag was also investigated.

Data presented is based on fly counts from ten cattle in each group over the four seasons, 1320 individual observations were made.

Fly populations varied considerably on the control cattle over the four seasons with mean fly numbers on ten cattle ranging between 118 and 374. The main fly species present in order of prevalence were Haematobia irritans, Musca autumnalis, Hydrotaea irritans, Haematobosca stimulans, Morellia simplex, Stomoxys calcitrans and Simulium reptans.

One cypermethrin/fenvalerate ear tag per animal reduced the fly population by between 86% to 97%, when compared to the control untagged cattle.

The investigation gave a better understanding of the level of fly worry on cattle under UK conditions and the protection/contentment that can be obtained with one synthetic pyrethroid insecticidal ear tag per animal.

## S15.2. 8 CATTLE FLY CONTROL USING SLOW-RELEASE PESTICIDES

D W TARRY

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During the four years 1980-1983 field trials were carried out on fly control using eartags impregnated with various synthetic pyrethroid pesticides, on Sussex farms having a problem with fly-transmitted disease. Although all the pesticides used (permethrin, cypermethrin and fenvalerate) demonstrated some effect on face-fly numbers (*M. autumnalis*) on the cattle, cypermethrin tags appeared to give the most effective reduction under the trial conditions; they also showed the fastest 'knock-down' effect on flies in laboratory contact tests.

## S15.2. 9 AMITRAZ IN THE CONTROL OF NON-IXODIDE ECTOPARASITES OF LIVESTOCK

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Intensification within the livestock industry has provided suitable conditions for the rapid propagation of ectoparasite conditions which require animal to animal contact. This situation is often complicated, when, for example, more than one family of mite may occur on an animal or within any group of animals. Acarine infestations may be complicated even further by the presence of e.g. lice, and finally the whole situation confounded possibly by the fact that some of the infestation may resist the chemicals that are routinely used.

Amitraz is capable of controlling effectively all concurrent mite and lice infestations of livestock.

Amitraz has been used successfully in many areas of the world to control single and mixed infestations of skin parasites of livestock. Generally conventional methods for the treatment of ectoparasites have been used but occasionally less common methods of application, exposure times to spray or dipwash and dose rates have been employed. These are discussed.

S15.2.  
10

## THE CONTROL OF LICE ON DOMESTIC LIVESTOCK

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In a recent survey surprisingly high levels of louse infestation were found on calves in Ayrshire (Titchener, 1983, *Veterinary Record* 112, 460). These animals were used in chemical control trials. Candidate chemicals, mainly synthetic pyrethroids and organophosphorus compounds, were compared with preparations currently available for louse control. These new compounds were applied as sprays, pour-on and spot-on treatments, impregnated tags and by systemic infection. Cypermethrin spray (Barricade, Shell) when applied at the concentration suggested for fly control also gave complete control of *Damalinia equi*, the biting louse of horses.

S15.2.  
11

## SOME OBSERVATIONS ON THE BIOLOGY AND CONTROL OF THE SHEEP SCAB MITE PSOROPTES OVIS IN BRITAIN

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Sheep scab was eradicated from Britain in 1952 but reappeared in 1973. Control is by single dipping in approved acaracides, HCH, diazinon or propetamphos. Approval is recommended by the laboratory only if the minimum use rate (maintenance level) will give at least 4 weeks protection. The method of testing is described.

All sheep are required by law to be dipped at least once a year in an approved dip. Traditionally this has been required during the winter when the disease has been thought to be the most active, the mites during the summer entering a latent phase. Recent observations at Weybridge, however, indicate that there is little difference between the summer and winter behaviour of the mites (*Psoroptes ovis*). In 1982 national dipping was required during the summer instead of the winter.

**515.2.** PHOSMET FOR THE SYSTEMIC CONTROL OF PIG MANGE  
**12**

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Pig mange caused by Sarcoptes scabiei var. suis is widespread throughout pig farms in the world. The present practice of scrubbing or spraying sows with an acaricide shortly before farrowing is time consuming and results of treatment depend very much on the diligence of the pigman.

Phosmet, in an oily concentrated solution, was developed as a pour-on solution which exerts an acaricidal effect throughout the integument. It has been shown that when sows were treated prior to farrowing, piglet growth rates and weights at weaning were significantly improved compared to control animals.

On a mange infested pig farm, treatment of growers with phosmet at weaning and on two subsequent occasions produced commercially significant improvement in daily live - weight gain.

**515.2.** PROGRESS ON CONTROL OF NORTHERN FOWL MITES ON CAGED LAYING HENS  
**13**

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The northern fowl mite (NFM) is the most important external parasite of chickens in the United States and in temperate areas throughout the world. The successful control of this mite must be compatible with integrated pest management under a variety of poultry husbandry practices and varied environmental conditions. This review will consider the mode of NFM distribution throughout the poultry industry and the available data on methods for controlling the spread of NFM on inanimate objects by either temperature or fumigation. Methods for controlling NFM populations on the host, such as new classes of chemicals or chemical application techniques, immunology and host genetics, will also be discussed.

**S15.2.** THE ROLE OF TAXONOMY IN THE CONTROL OF THE  
**14** FLIES OF GRAZING CATTLE AND SHEEP

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The great majority of the secretophagous and blood-sucking flies, which are pests of cattle, develop in cattle droppings. Chemical control of those flies are costly, yet not effective enough, since new chemicals have only been used with the old methods, and the differences in life-habits of the dipterous species are neglected. The actual size of populations and the true dominance of the pest species cannot be estimated on the basis of flies counted or caught on cattle or in their surroundings but by rearing flies from droppings only. Besides *Musca autumnalis* and *Haematobia irritans*, the importance of numerous other secretophagous muscid species is stressed. It seems probable that owing to the major differences in the biology of the pest species, no single method can be effective enough, i.e. a complex of control methods is to be worked out. Thirty-one dipterous species have been reared from droppings of grazing sheep incl. some of veterinary importance. The sheep droppings in Hungary have no autochthonous dipterous community but all the species reared have also been reared from cattle droppings /the dominance of the species is different/; data were also collected on population interactions of flies, beetles and mites.

**S15.3.** CELL BIOLOGY OF THE SALIVARY GLAND  
**1** OF RHIPICEPHALUS APPENDICULATUS

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The salivary gland of *R. appendiculatus* contains three types of acini. The type I acinus, concerned with osmoregulation, is lined by a transport epithelium with an extensive basolateral extracellular labyrinth and changes little during feeding. The excess fluid taken in with the blood meal is disposed of by secretion of a copious saliva which is ejected into the bovine host. This is achieved mainly by acinus III consisting of three glandular cell types (d, e, and f-cells) and two categories of interstitial cells (adluminal and abluminal). The f-cells, undifferentiated prior to attachment, rapidly develop into protein secreting cells which function in this role for two days. Their secretory organelles are then eliminated by autophagy and they are rapidly transformed to form with the interstitial cells an elaborate transporting epithelium. Associated with this dramatic cytomorphosis is the development of a profusion of gap-junctions which may provide channels for ion flux from the transformed f-cells to the adluminal interstitial cells.

Additional observations on structural changes in acinus II during feeding; on acinus IV of the male; and on innervation of the gland will be presented.

**15.3.2** TICK ECDYSTEROIDS: CHEMISTRY, FUNCTION & METABOLISM

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Ecdysteroids, the well known moulting hormones of insects and crustaceans, are also present in immature and mature stages of both argasid and ixodid ticks. In this review, we will summarize our current knowledge about the chemistry, the possible functions, and the metabolism of these hormones. In addition, we will also discuss the effects of exogenous ecdysteroids after topical application, injection or ingestion.

**15.3.3** ROLE OF ECDYSONE IN SALIVARY GLAND DEGENERATION IN THE FEMALE TICK  
AMBLYOMMA HEBRAEUM (ACARI: IXODIDAE).

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Following the bloodmeal, ixodid ticks lay a single batch of eggs and die. To date we have only indirect evidence to suggest that juvenile hormone and ecdysone influence vitellogenesis in ticks. During the first week postengorgement, several tissues are reabsorbed, notably the endocuticle and the salivary glands. My laboratory has demonstrated that reabsorption of the salivary glands is triggered by a 'tick salivary gland degeneration factor' (TSGDF; J. Insect Physiol. 27 (1981):241-248; J. exp. Biol. (1984) in press). Here I shall review (1) the evidence for hormonal regulation of salivary gland degeneration (2) how copulation influences the latter process and (3) evidence that TSGDF is an ecdysteroid.



### **S15.3.** WATER BALANCE BY TICKS BETWEEN BLOODMEALS **4**

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Ticks live for months or years without feeding. Between blood-meals they obtain water from unsaturated air by passive diffusion, and by an active uptake mechanism above the critical equilibrium humidity (CEH). Below the CEH passive uptake is the only significant source of water, and the uptake rate is dependent upon the ambient temperature and humidity. Transpiration rates are constant over the humidity range of 0-92.5%, and averages  $0.00497 \text{ hr}^{-1}$  at  $26^\circ\text{C}$  for female lone star ticks. The mouth is the site of active uptake, and in the lone star female this accounts for 23-34% of the total amount absorbed. The active uptake mechanism involves the type I agranular acini of the salivary glands which secrete a salt solution containing primarily Na, K, and Cl. In vivo dopamine-stimulated saliva is dilute and the ion concentrations are 252, 63, and 227mM, respectively. The central lamellate cell of the type I acinus most likely secretes this fluid as it is the only transport cell which borders both the hemolymph and lumen. Na,K-ATPase activity is concentrated in basal membrane infoldings of central and peripheral (pyramidal) lamellate cells. Ultrastructural changes in these cells during tick dehydration and rehydration verifies their involvement in the process. Active water uptake will be understood only when saliva from rehydrating ticks is characterized.

### **S15.3.** LETHAL ORAL SECRETIONS OF THE AUSTRALIAN PARALYSIS TICK IXODES HOLOCYCLUS AND THE ROLE OF THE SALIVARY GLAND IN TOXIN BIOSYNTHESIS **5**

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A lethal paralyzing toxin (holocyclotoxin) secreted by the Australian paralysis tick, has been detoxified and now forms the basis for an experimental toxoid vaccine. A better understanding of biosynthesis of holocyclotoxin by the salivary gland may provide valuable information to assist in possible production of the active antigen by means of biotechnology. Progress in research into these aspects will be described.

### **S15.3.** CHARACTERIZATION OF TICK ANTIGENS RESPONSIBLE FOR INDUCTION 7 OF HOST RESISTANCE

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Naive guinea pigs passively immunized with crude salivary gland extract from 6 day fed Amblyomma americanum females expressed significant tick rejection (40-50%) when challenged 17 days later. The minimum effective dose of crude SGA was 250ug, and was immunogenic in Incomplete Freund's adjuvant or saline, not in Complete Freund's adjuvant. Preparations of gut extract and cement material were weakly immunogenic. Protease activity was not of importance because SGA preparations with or without protease inhibitors exhibited similar immunogenicity. Initial characterization of tick proteins responsible for induction of host resistance was achieved with SDS/PAGE of immunoprecipitated <sup>125</sup>I salivary gland proteins. Autoradiograms of gels indicated that polyclonal guinea pig anti-tick serum recognized a single protein (20,000mw) in both female and male ticks. Analysis of salivary glands from ticks at various times during feeding revealed the consistency of this protein in both sexes. Rocket and two dimensional immunoelectrophoresis of SGA into rabbit anti-tick antibody demonstrated a similar profile of antigen kinetics. Partial purification of skin reactive antigen from crude SGA was achieved by molecular sieve (G-75), ion-exchange (DEAE) and immunoabsorbant (guinea pig anti-tick IgG<sub>1</sub>) column chromatography. In summary, animals can be immunized against tick feeding with salivary gland extract, immunogenic activity appears to be due to a 20,000mw protein, and various chromatographic procedures each yield a single peak that induces strong immediate skin reactions in actively sensitized hosts.

### **S15.3.** FECUNDITY-REDUCING PHEROMONE IN ARGAS (PERSICARGAS) ARBOREUS 8 (IXODOIDEA: ARGASIDAE)

GALILA M. KHALIL

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Fed adult Argas (persicargas) arboreus produce a fecundity-reducing pheromone which affects all or most females in crowded conditions. Unfed adults and unfed and fed nymphs do not produce this pheromone. The effect of this pheromone is probably additive, increasing with additional crowding of adults. Mechanical disturbance is excluded as the cause of fecundity reduction. Fed females separated by a perforated barrier from crowded adults also exhibit very low fecundity. Adult excretory materials used 31 days post-feeding do not contain the fecundity-reducing pheromone. Preliminary experiments suggest that this pheromone is spatially limited in action, does not affect gonadotropic hormone synthesis and/or release, and does not induce oviposition deterrence behaviour. This may be considered to be a primer pheromone, causing alteration in normal vitellogenin synthesis and/or uptake and deposition in oocytes.

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Mating and feeding are usually necessary for oogenesis and oviposition in ticks except for the few parthenogenetic and autogenous species. Reproductive strategies differ between the soft ticks (Argasidae) and hard ticks (Ixodidae) and a complex interplay among the various stimuli involved in mating, feeding and oviposition occurs in different species. Scarcity of data and reported differences among the species precludes any general hypothesis at this time regarding induction of oviposition that is applicable to all cases even within the same family. Apparently there is a complicated interplay among the nervous, endocrine and reproductive systems prior to and during egg maturation and oviposition. Some of the published data concerning these processes are reviewed and new information added.

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Blood meal digestion occurs intracellularly in ixodid midguts. Uptake of the blood meal occurs via coated pits and flask-shaped vesicles. The contents of the coated vesicles are stored in endosomes. Digestion begins with the fusion of endosomes and primary lysosomes to form secondary lysosomes and ends with the accumulation of residual bodies. Digestion occurs in 3 phases in mated females, but only 1 phase in fed males. Unmated females show 1 phase but unmated ovipositing females have 3 phases. One type of digestive cell is found in the midgut. A second cell type, the putative vitellogenic cell, appears in the midgut of mated females and in unmated ovipositing females. This vitellogenic cell type is not seen in unmated non-ovipositing females or in males. Complete immunological identity exists between vitellogenin from the midgut, fat body, hemolymph, and vitellin from eggs. We hypothesize that the same vitellogenin is synthesized by both the midgut and fat body, then is released into the hemolymph to be transported to the ovary. We further hypothesize that vitellogenin is taken up, unaltered, by the ovary where it is changed to vitellin.

S15.3.  
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#### TICK PHEROMONES: AN OVERVIEW

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Ticks use pheromones for intra-specific communication. Known types include Assembly, Aggregation/attachment, and Sex pheromones. Assembly pheromones may induce clustering among questing ixodids on stems or branches of vegetation, as well as assembly of nidicolous argasids. Aggregation/attachment pheromones are volatile compounds that attract conspecific individuals of certain Amblyomma species to feeding sites on a host. O-nitro-phenol has been identified as a component of the aggregation and attachment pheromone in Amblyomma variegatum and similar compounds may be expected to serve this role in other species of this genus. Sex pheromones of Ixodidae include both a volatile, non-specific sex attractant, and a species-specific genital pheromone. Recent evidence implicates ecdysteroids in the development of the pheromone glands and the physiological stimulation of sex pheromone production. Other evidence implicates catecholamines in the regulation of pheromone secretion. Sex pheromones of Argasidae are released in the coxal fluid, and coat the body surface of female ticks. The evolution of tick pheromone appears to have been fortuitous, though phenolic compounds have been adapted for use in this role to a greater degree than any other.

S15.3.  
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#### ASPECTS IN THE METABOLISM OF ORGANIC ACIDS BY DERMACENTOR ANDERSONI (IXODIDAE, ACARINA)

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SOME aspects of organic acid metabolism in the ovipositing Dermacentor andersoni was studied by tracing the fate of pyruvate-1-C, acetate-1-C, citrate-1,5-C, and glyoxylate-u-C after injection of their solutions into the hemocoel of this tick. The incorporation of the injected organic acids into CO<sub>2</sub>, carbohydrates, amino acids, and lipids was used as a qualitative index for the operation of certain reactions and routes for their metabolism. The results indicate the operation of a modified citric acid cycle. This cycle is operating from both ends that lead to the formation of tri-, and dicarboxylic acids. A possible contribution of glyoxylate as an intermediate metabolite in organic acid metabolism is also indicated.

**S15.3.** ON THE BEHAVIOURAL RESPONSE OF *EHIPICEPHALUS SANGUINEUS*  
**13** TICK TO LIGHT, RELATIVE HUMIDITY AND HOST ODOUR

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EGYPT

Hydrated unfed ticks at different developmental stages exhibited, in an alternative chamber, clear photopositive and hygropositive reactions, but their preference to dryness surmounted their reaction to light. Engorgement reversed their reaction to light but not to relative humidity. Unfed females were more sensitive to desiccation than males; both sexes became hygropositive after 6-week period of desiccation. Unfed ticks responded to the odour of dog's hair more strongly than to rabbit's fur. Masking the fore tarsi carrying Haller's organ eliminated the response of unfed ticks to relative humidity but entirely to host odour. All stages showed negative geotaxis except fully fed females. Other experimental details are also given and discussed.

**S15.3.** IXODID TICKS OF CATTLE AND SHEEP IN  
**14** THE PROVINCE OF ANKARA IN TURKEY

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Ixodid ticks of cattle and sheep and their seasonal fluctuations were determined at six localities, representing the province of Ankara. 20 cattle and 20 sheep from each locality were examined monthly for the tick infections and 5943 ticks were collected from May 1982 to April 1983. *Rhipicephalus* and *Hyalomma* spp. were collected in spring and summer, *Haemaphysalis* spp. and *Dermacentor marginatus* in Autumn and winter. Infection of the animals with *R. sanguineus* were seen 2 months earlier than *R. bursa*. Percentage of the ticks collected from animals were 19.4 *R. sanguineus*, 10.4 *R. bursa*, 1.3 *H. a. anatolicum*, 4.5 *H. m. marginatum*, 0.8 *H. m. turanicum*, 59.8 *H. otophila*, 0.2 *H. punctata* and 0.6 *H. sulcata* in the years of 1983-1984.

### 15.3. TICK POPULATION ON TWO BREEDS OF CATTLE UNDER FIELD CONDITIONS

15

RECHAV, Y

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A survey of ticks collected from two breeds of cattle in the Northern Transvaal Province of South Africa was carried out over a 2 year period

Amblyomma hebraeum, Phipicephalus appendiculatus and R.e. evertsi were abundant. It was found that Hereford carried significantly more adult ticks of the abovementioned 3 tick species, when compared with Brahman grazed together with the Hereford. Blood samples taken from Hereford and Brahman were correlated with the density of tick populations collected from the two studied breeds of cattle

### 15.3. DISTRIBUTION ON THE HOST(BIRDS) OF TWO SYMPATRIC SPECIES OF TICKS(ACARI):

17 IXODES RICINUS AND HAEMAPHYSALIS PUNCTATA IN A FOREST OF SWITZERLAND

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Between the 9.3.1982 and the 31.5.1982, 282 birds of 34 species were caught in a forest near Martigny (Valais, Switzerland). 156 larvae, 142 nymphs of Ixodes ricinus L. and 78 nymphs of Haemaphysalis punctata Can. & Fanz. were collected on their heads only, and none on the rest of their bodies. 98 % of the larvae and 90 % of the nymphs of I. ricinus were on the edge of the bill and around the eyes (resp. 1 % and 7 % on the throat) and 75 % of the nymphs of H. punctata were on the throat (9 % on the edge of the bill and the eyes). The influence of the competition between two sympatric species for a site of attachment is discussed.

\* part of a ph.D. thesis at the University of Neuchâtel (Switzerland).

**S15.3.** PREVIOUS NOTE CONCERNING TO AN ORGANIZATION OF A CATALOGUE  
**18** FOR THE GENUS APONOMMA NEUMANN, 1899 (ACARINA-IXODOIDEA)

J.A.TRAVASSOS SANTOS DIAS

CENTRO DE ZOOLOGIA - INSTITUTO DE INVESTIGAÇÃO CIENTÍFICA TROPICAL - LISBON

Among the several genera belonging to the family Ixodidae Murray, 1877 the genus Aponomma Neumann, 1899 is the only one (excluding those that are monotypic - Anocentor Schulze, Nosomma Schulze, Cosmiomma Schulze, Anomalohimalaya Hoogstraal et al. and Dermacentonomma T.Dias) which has not representatives in the Palearctic and Neotropical Regions.

In spite of the few number of Aponomma species presently known there are several doubts regarding the correct identification of the some of them.

In order to prepare a catalogue for that genus, we decided to elaborate and identification key for the males of the species considered as valids by us.

Also, a list of their synonyms and an account of the respective distribution were organized.

**S15.4.** STATUS AND POTENTIAL OF BIOLOGICAL CONTROL AGENTS IN LIVESTOCK  
**1** AND POULTRY PEST MANAGEMENT SYSTEMS  
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The major groups of predators, parasites and microbial agents affecting arthropod pests of livestock and poultry are surveyed and their historical, present and potential practical importance evaluated. The status and potential for using predators and parasites in livestock and poultry pest management systems are analyzed in relation to changing animal production systems and evolving concepts and practices of integrated pest management (IPM). Particular attention is given to the role of biological control in confined animal operations and integrated animal production systems.

**S15.4.** INVESTIGATION, IDENTIFICATION, REARING, SELECTION OF INSECT PARASITES  
**2** OF FILTH BREEDING FLIES IN EUROPE FOR INTRODUCTION INTO THE UNITED STATES OF AMERICA

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Parasitic hymenoptera attacking the pre-imargo stages of several filth breeding flies were collected in Europe. These were identified and reared for subsequent shipment to the USA. Most of the parasites belong to the family pteromolidae and in the genera Spalangia and Muscidifurax. These parasites are currently being cultured and evaluated for their efficiency in the USA.

**S15.4.** SOME ASPECTS OF BIOLOGICAL CONTROL OF FILTH FLIES IN CHILE AND  
**3** EASTER ISLAND

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Instituto de Investigaciones Agropecuarias, Subestacion Experimental LaCruz  
Casila 3 LaCruz, Quillota, Chile

A survey has been made of the parasitoids, predators and competitors of filth breeding flies on Easter Island and Central Chile. On Easter Island no parasitoids and very few predators were found which attack muscoid flies. Only one species of small dung beetle was observed on the island. Therefore, muscoid and other filth breeding flies are a serious nuisance. Numerous parasitoids, predators, and competitors have been collected in the central area of Chile. Once these are identified and cultured, they will be introduced to Easter Island to establish a natural biocontrol system there to help suppress the fly populations.



**S15.4.** PARASITE MONITORING AND IMPACT EVALUATION IN THE DEVELOPMENT OF FILTH  
**4** FLY BIOLOGICAL CONTROL PROGRAMS FOR POULTRY FACILITIES

DONALD A. RUTZ

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Filth fly parasite monitoring techniques used in poultry production facilities are compared and their inherent problems presented. Parasite impact evaluation techniques, including changes in filth fly populations and rates of pupal parasitism, are examined. The significance of parasite monitoring and impact evaluation in the development and assessment of the biological component of integrated filth fly management programs for poultry production facilities is discussed.

**S15.4.** EVALUATING THE IMPACT OF PARASITE RELEASES ON FILTH FLY  
**5** POPULATIONS ASSOCIATED WITH CONFINED LIVESTOCK INSTALLATIONS

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The increased promotion of pteromalid wasps as biocontrol agents of filth flies associated with confined livestock has resulted in a controversy as to the effectiveness of these parasites. The discrepancies, at least in part, come from inherent problems associated with evaluation of the effectiveness of the release.

The inaccuracies associated with the placement and handling of sentinel pupal populations to measure parasite activity are discussed. Also, inaccuracies associated with evaluations based on sampling of wild pupal populations are detailed with emphasis on problems caused by removal of populations while still subject to attack, the accumulation factor resulting from the longer life cycle of the parasite, and the number of hosts killed by the parasites yet fail to produce parasite progeny.

15.4.  
6

BIOLOGICAL CONTROL OF STABLE FLIES (STOMOXYS CALCITRANS AND S. NIGRA)

D. J. GREATHEAD

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Numerous parasitoids were collected, colonized and released in an effort to control stable flies on Mauritius. Some of the species were collected in Uganda and later shipped to the island where they became established. This effort demonstrated the importance of habitat in host selection by parasitoids of muscoid pupae and the need to employ natural enemies suited to the target habitat in the biological control of synanthropic flies.

15.4.  
7 BIOCONTROL OF HAEMATOBIA THIROUXI POTANS IN BUFFALO DUNG IN RELATION  
TO SOIL AND VEGETATION TYPE DIFFERENCES

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Haematobia thirouxi potans (Bezzi) is a fly in Africa whose blood-feeding adult stage is commonly associated with buffalo (Syncerus caffer). Biocontrol of its immature stages in buffalo dung has been examined in areas of different soil and vegetation type. The mean number of flies surviving in dung pads exposed to all fauna as a function of the mean numbers surviving in pads untouched by control agents was used as an index of biocontrol effectiveness. Statistical consideration of the indices associated with different areas suggested significantly better faunal control of the fly in grassland on sandy loam - loam soil than in similar vegetation on heavy clay. No such difference was established between these soil types when they were covered by bush.

## S15.4. 8

### BIOCONTROL OF THE BUFFALO FLY : AN ANALYSIS OF THE POTENTIAL OF THE AFRICAN DUNG FAUNA

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The buffalo fly *Haematobia irritans exigua* is a blood-feeding pest of cattle in the moist sub-tropical regions of northern Australia. This fly does not occur in climatically homologous regions of southern Africa where its ecological equivalent, the African buffalo fly, *Haematobia thirouxi potans*, occurs in relatively low numbers on cattle. The larvae of both species breed in cattle dung.

The African dung fauna contains a far greater diversity of species of dung beetle and of putative predators/parasitoids of dung breeding flies than does the fauna of climatically equivalent regions of Australia. Many of the African species show a preference for cattle dung and an open grassveld environment: such species are relatively rare in Australia.

The biocontrol potential of the African dung fauna for *H. thirouxi potans* is being compared with that of the Australian dung fauna for *H. irritans exigua* and promising differences are evident.

## S15.4. 9

### MODELS AND COMPUTER SIMULATIONS FOR BIOLOGICAL CONTROL OF FLIES

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The dynamics of populations of the house fly, a pupal parasite of house flies, and a predator of immature stages of house flies are simulated in computer analyses by varying key biological parameters regulating development, fecundity, and growth. Laboratory experiments describing the interactions of these biological control agents with house fly populations are used to simulate host/parasite and predator relationships and the degree of control obtained with and without inundative releases of the biological control agents. Patterns of releases of single or combined biological control agents resulting in effective control are illustrated.

**S15.4.** MASS CULTURING MICROHYMENOPTERON PUPAL PARASITES (DIPTERA:  
**10** PTEROMALIDAE) OF FILTH BREEDING FLIES.

PHILIP B. MORGAN

USDA-ARS, Insects Affecting Man and Animals Research Laboratory,  
Gainesville, Florida 32604

A procedure for mass culturing parasitic wasps was devised. This sequence,  
when followed, insures a weekly production of ca 13,000,000 parasites.

**S15.4.** COLONIZATION AND RELEASE OF INTRODUCED SPECIES OF DUNG-BURYING  
**11** SCARABS

G. T. FINCHER

USDA-ARS-VTERL

P. O. Drawer GE, College Station, Texas 77841

Seven exotic species of dung-burying scarabs have been colonized in Texas  
and 5 species have been released. Thus far, only 2 species have become  
established in the state, but additional introductions and releases are  
planned.

**S15.4.** THE ROLE OF PARASITES AND PREDATORS AS BIOLOGICAL FLY CONTROL AGENTS  
**12** IN POULTRY PRODUCTION FACILITIES

RICHARD C. AXTELL<sup>1/</sup> AND DONALD A. RUTZ<sup>2/</sup>

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<sup>2/</sup>Department of Entomology, Cornell University, Ithaca, NY 14853 USA

A summary of hymenopterous parasite species occurrence and relative abundance in caged-layer and broiler-breeder poultry facilities in different geographic regions is presented. The effect of releases of indigenous strains of Muscidifurax raptor and Spalangia cameroni on house fly numbers and rate of pupal parasitism is discussed. The biology and behavior of selected promising parasites as biological fly control agents are examined. A summary of predaceous beetle and mite species occurrence and relative abundance in poultry production facilities is presented and their behavior and effectiveness as filth fly predators compared. Integration of the use of parasites and predators in filth fly management programs is discussed.

**S15.4.** INCORPORATION OF THE PUPAL PARASITOID SPALANGIA ENDIUS IN AN  
**13** INTEGRATED PEST MANAGEMENT (IPM) SCHEME TO SUPPRESS FILTH FLIES.

R. S. PATTERSON AND P. B. MORGAN

USDA-ARS, Insects Affecting Man and Animals Research Laboratory  
Gainesville, Florida 32604

The pupal parasitoid Spalangia endius has successfully been used in conjunction with conventional control techniques to suppress house flies and other filth breeding flies at poultry and dairy installations. This parasitoid competes favorably in areas of high humidity and the media containing the host is moist. It will not compete if the media is wet. Sustained releases of this parasitoid in conjunction with baits and manure management practices have shown the most promise for fly control.

**S15.4.** BASIC AND APPLIED ECOLOGICAL INVESTIGATIONS OF PTEROMALID PARASITES AS-  
**14** SOCIATED WITH FILTH FLY DEVELOPMENT ON CONFINED LIVESTOCK INSTALLATIONS

JEFFERY A. MEYER<sup>1</sup> and JAMES J. PETERSEN<sup>2</sup>

<sup>1</sup>Cooperative Extension, University of California, Riverside, CA 92521 USA

<sup>2</sup>ARS-USDA, Dept. of Entomology, University of Nebraska, Lincoln, NE 68583 USA

Samples of house fly and stable fly pupae from various breeding sites on confined livestock installations yielded at least seven species of pupal parasites, with Muscidifurax spp. and Spalangia nigra showing significant (P = 0.01) preferences for house flies and stable flies, respectively.

Sequential releases of laboratory reared S. endius for 13 weeks on two bovine feedlots were ineffective in controlling house fly and stable fly populations under the conditions imposed and the numbers released.

**S15.4.** BENEFICIAL ARTHROPODS INHABITING BOVINE DROPPINGS IN THE UNITED STATES  
**15**

R. L. HARRIS

USDA-ARS-VTERL

P. O. Drawer GE, College Station, Texas 77841

Arthropods were collected from bovine droppings in east central Texas. The most abundant predators of the horn fly, Haematobia irritans irritans, were the staphylinid beetles; while the most abundant competitor was the brown dung beetle Onthophagus gazella. The dominant horn fly pupal parasites were Spalangia cameroni and Spalangia nigroaenea.

**S15.4.** THE REQUIREMENT FOR EXPANDED SCIENTIFIC STUDY INTO INTERACTIONS  
**16** BETWEEN DUNG BEETLES AND SYMBOVINE FLIES

E. F. LEGNER

Division of Biological Control

University of California, Riverside, California 92521, USA

Firmly established scarab populations in the Coachella Valley of California thoroughly scatter cattle dung; but Haematobia irritans (L.) densities remain unacceptably high. Scarab interference with physical controls and resident natural fly predators may be involved.

**S15.4.** ASPECT OF THE PREDATORY ACTIVITY OF MACROCHELES PEREGRINUS  
**17** (MACROCHELIDAE) ON TWO SPECIES OF HAEMATOBIA FLIES

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Dung Beetle Research Unit

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In laboratory tests, increasing the density of the Macrocheles peregrinus from one mite per 10 eggs to one mite per 2.5 eggs caused a marked increase in mortality of Haematobia thirouxii but only a limited increase with Haematobia irritans. The two species show different mortality responses when mites were confined with fly eggs at various intervals after oviposition.

**515.4.** ELECTROPHORETIC STUDIES OF PARASITIC HYMENOPTERA AND IMPLICATIONS  
**18** FOR BIOLOGICAL CONTROL

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Division of Biological Control, Department of Entomology  
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Isozyme electrophoresis of an isolated field population of Bathypectes curculionis has resulted in the discovery of diploid males. Furthermore, the sex ratio of this population is male biased suggesting that inbreeding has disrupted a Habrobracon type of sex determination. A survey of genetic variability at 17 enzyme loci for 17 populations in the genus Aphidius is presented and genetic relatedness within and between species is examined. These two very distinct studies are compared and are used to provide general comment on future biological control efforts.

**515.4.** ISOENZYME CHARACTERIZATION OF INTRA- AND INTERSPECIFIC VARIANTS  
**19** OF PARASITIDS OF SYNANTHROPIC DIPTERA

DR. GARY D. PROPP  
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The technique of isoenzyme analysis has been used to identify biotypes of four species of Spalangia found parasitizing pupae of synanthropic Diptera in the U.S. Variation in isozyme patterns has also been used to help clarify the taxonomic status of species of Spalangia and Muscidifurax.



**\$15.5.** RIVISED LISTING OF THE CULICOIDES (DIPTERA: CERATOPOGONIDAE)  
**1** OF TAIWAN

KITAOKA, S. (NATIONAL INSTITUTE OF ANIMAL HEALTH, TSUKUBA, JAPAN)  
AND TANAKA, K. (INSTITUTE OF MEDICAL SCIENCE, TOKYO, JAPAN)

Following the first contributions by Kieffer (1912) and Shiraki (1913), McDonald and Lu (1972) compiled comprehensive data on the Taiwan Culicoides, discribing 34 taxa and a key for females. In the authors' survey in this island during 1982 and 1983, 14 new records of the species and 4 new species were identified. They belong to the subgenus Culicoides s. str., Haemophorctus, Trithecoides and the groups of neavei and similis. Known in Taiwan were altogether about 60 species and the males of 53 species of Culicoides, including additional records given by some previous workers. Discussion was also made on the enzootic significance of geographical situation for the outbreak of Culicoides-borne diseases of cattle in Japan.

**\$15.5.** BIONOMICS OF FORCIPOMYIA (LASIOHELEA) TAIWANA (SHIRAKI, 1913)  
**2** (DIPTERA, CERATOGONIDAE) IN HUALIEN, TAIWAN

CHIN-SENG CHEN, Medical Entomology Section, Taiwan Provincial Institute of Infectious Diseases, Nankang, Taipei, Taiwan, R.O.C.

Forcipomyia (Lasiohelea) taiwana (Shiraki, 1913), a notorious blood-sucking midge of man, is abundant in certain areas of Taiwan, especially on the estern parts of the island. A routine survey has been made in Hualien Hsien once/twice a month since June 1976. Some preliminary results of this study are summarized as follows:

LARVAL BREEDING SITES. All larvae were found on the soil surface. Although the larvae are terrestrial, the water content of soil is one of the important factors for larval breeding. On the other hand, most of these breeding places were always found mossy. Actually, it is an indicator in search of the larvae.

ADULT RESTING PLACES. The adults were captured with D-Vac vacuum sweep net outdoors at night. The two important resting places of this midge are shrubs and wild grasses.

BITING PATTERN. As a result of hourly biting catch with human bait, the landing rate of the midges increased between 0800 and 1400, with clear peak at 1400, a shallow depression at 1100, and gradually decreasing toward dusk.

SEASONAL ABUNDANCE. Monthly catches with human bait revealed that the population size of the midges increased gradually from January to July and decreased sharply from August to December. The relationship between the fluctuation of the midges and certain meteorological factors are discussed.

**S15.5.** Seasonal abundance of Culicoides (Diptera: Ceratopogonidae)  
**3** from coastal Georgia (U.S.A.)

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Species of adult Culicoides present, their seasonal abundance and geographical distribution in coastal Georgia, particularly Sea Island, a coastal barrier island, were examined using CDC miniature light traps, emergence traps and sticky cylinder traps during 1982, 1983 and 1984. Nine species were collected. The three most abundant species (comprising more than 95 percent of total biting midges collected) are listed in order of abundance: C. furens (Poey), C. hollensis (Mellander and Brues), and C. melleus (Coquillett). The remainder of the species present were C. haematopodus Malloch, C. insignis Lutz, C. obsoletus (Meigen), C. mississippiensis Hoffman, C. venustus Hoffman, and C. paraensis (Goeldi). The following species are reported for the first time from Georgia: C. mississippiensis and C. insignis.

**S15.5.**  
**4**

A.M. PUCAT  
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A description of the immature stages of Alluaudomyia megaparamera is given. This species is compared with some other species of Alluaudomyia and with some Culicoides spp. from Canada. Included also is a discussion of key characters for distinguishing pupae of Alluaudomyia, Culicoides, and some other genera of Ceratopogonidae.

**\$15.5.**  
**5**

## RESPONSES OF LARVAL CULICOIDES VARIIPENNIS TO LIGHT

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Larvae of the U.S. bluetongue virus vector Culicoides variipennis vary tremendously in their response to light. Long-term studies at a field site in southern California suggest that light response is a complex cyclical phenomenon, perhaps related to voltinism. When severely disturbed, larvae often retreat from light, even if they are in a photopositive period. Other factors involved in the light response may include age and nutritional status. Shading experiments conducted in the field indicate that larvae generally prefer sediments open to sunlight. This preference also may be influenced by larval age and associated environmental variables such as heat, food availability, or distribution of other macroinvertebrates.

## **\$15.5.** Maintenance of Culicoides nubeculosus (Diptera: Ceratopogonidae) in the **6** laboratory for experimental infections with microfilariae.

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Culicoides is the most important genus of Ceratopogonidae in medical parasitology. Several species are vectors of nematodes (filariae) and viruses. In order to obtain great numbers of infective filarial larvae for various subjects we maintain a colony of a strain of Culicoides nubeculosus - natural vector for Onchocerca cervicalis and O.gutturosa in Europe - which is colonized in the laboratory. The adults kept in gauze-cages at 25-26°C and 90 % relative humidity are offered a 20 % aqueous sugar-honey solution. The females are fed either on various rodents or artificially on Latex-membranes with blood of various sources, a technique already successfully used to feed simuliids (WIRTZ, 1983). The kind of feeding influences the oviposition and the number of eggs hatched. The egg-batches can be stored at +5°C on wet cotton and can be induced to hatch when necessary. In preliminary trials the females took up microfilariae of Onchocerca volvulus and from fresh hides of red deer O.flexuosa, O.tubingensis and Cutifilaria wenki through artificial membranes. Additionally the females were offered microfilariae of Litomosoides carinii from cotton rats and of Dipetalonema viteae from jirds. So far no further development of microfilariae has been found in the females. But the limited number of these infection trials does not allow to exclude Culicoides nubeculosus as a potential or experimental vector of the filariae mentioned. From former investigations we got distinct hints that some of the filariae of red deer should be transmitted by Culicoides (SCHULZ-KEY and WENK, 1981).

**S15.5.** Pioneer settlement of biting midges (Diptera,  
**7** Ceratopogonidae) in sewage ponds.

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In 1982 at the sewage purification plant SCHWARZBACHTAL five sewage ponds were installed to receive better purification results. Each pond is in connection with the following by a ground joist (beam) of rubble (stones). The water quality is from poly- to  $\alpha$ mesosaprob. As pioneer midges settled in the first and second pond *Culicoides circumscriptus* and *C. odibilis*. From the third to fifth pond *C. riethi* was found together with *C. circumscriptus* and *C. odibilis*. The genus *Culicoides* was found in all sewage ponds, whereas *Bezzia* settled only in the fifth pond with the species *Bezzia nobilis* and *B. nigrita*. The ground joists were settled earlier by the *Bezzia* species *B. nobilis* and *B. strobli*. These two species were still found in the second beam. Totally 9 species of biting midges could be varified in this water: *C. clastrieri*, *C. circumscriptus*, *C. odibilis*, *C. riethi*, *B. nigrita*, *B. strobli*, *B. nobilis*, *Forcipomyia titillans* and *Dasyhelea spec.*

**S15.6.** INSECT COMPOUND EYES: SOLUTIONS TO  
**1** THE PROBLEMS OF DETECTING FORM AND COLOR.

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The visually mediated behavior of diptera is complex. Their eyes contain specializations for high spatial acuity, for spectral ("color") discrimination, for contrast enhancement of object against background, and for detection of polarized light. After introducing the dipteran compound eye and its specializations, the corneal interference filters shall be discussed.

These filters are comprised of specialized cuticular layering at the anterior corneal surface. They serve to create colored eye patterns and to tint light that reaches the retina. Evidence from comparative study of reflectance and transmittance spectra, correlated with ecological data, shows that some species use corneal layering only as a means of creating eye patterns, while other species use corneal layering as color filters that modify contrast in particular spectral bands. Recent work shows that some filters are effective in reducing transmittance in the near-ultraviolet band.

## S15.6. THE IMPORTANCE OF VISION TO ORIENTATION BY MOSQUITOES

2

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32962

Mosquitoes have long been known to use olfactory cues when orienting upwind toward hosts. Visual orientation of diurnal mosquitoes toward hosts and inanimate objects has also been documented. Results from field experiments (Birlingmayer) and laboratory wind tunnel experiments (Day) show that many crepuscular-nocturnal mosquitoes (eg. Culex quinquefasciatus, Culex nigripalpus, and Anopheles quadrimaculatus) rely heavily on vision for orientation, during both the preceding searching flight and the upwind flight to a host.

## S15.6. VISUAL ORIENTATION AND COLOUR VISION IN TSETSE

3

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Previous largely subjective observations on the importance of colour in the design of tsetse fly traps, together with laboratory observations on spectral responses of Glossina, have led to an evaluation of tsetse fly colour responses in the field. Materials tested were selected on the basis of visible and near-ultraviolet reflectivity, as tsetse visual sensitivity spans both regions. Two species of Glossina were present in the study area (the Zambezi valley in Zimbabwe), G. pallidipes and G. morsitans. The effectiveness of one design of trap was determined when colour was varied on different outer and inner portions of the trap, and the large differences obtained between the different treatments were further investigated by placing electrocuting nets (invisible to tsetse flies) near to coloured traps and surfaces. Two distinct types of attractive response were observed, to blue and to dark objects. Reflectivity in green and possibly also near-ultraviolet wavelengths lowers the attractiveness of a surface. Responses of flies to colours were compared with those to a range of greys, and it was found that both the least and the most attractive colours (green and blue, respectively) produced responses outside of the range of responses to greys. These and other findings imply that Glossina employs true colour vision in visual orientation.

## 515.6. Visual orientation in Tabanids

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The intermediate position of the Tabanidae in the evolution of hematophagous Diptera will be discussed with respect to sensory modalities. The primary use of vision in host location in this group makes the tabanids an ideal model system for examination of visual ecology in blood feeding flies. Using a salt marsh species (Tabanus nigrovittatus) as a model system, the relative roles of target hue, intensity, size, shape, pattern complexity and background contrast in attraction of flies seeking a blood meal will be discussed. This information will be integrated with electrophysiological data.

## 515.6. VISUAL ORIENTATION IN BLACK FLIES

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Detailed studies elucidating all components of host seeking by black flies are not possible because these flies do not behave normally when confined. Field observations suggest that black flies do not directly embark on host seeking flights but instead sit in elevated perches and wait for hosts to come into their range. The generalized host seeking process of these diurnal biters is reported to consist of 3 ill-defined hierarchical stages. Long range orientation is dependent upon chemical cues and possibly initial visual sighting of the host. Middle range orientation involves both visual and carbon dioxide cues. Close range orientation is the final approach to the host and landing. Black flies can discriminate among body regions of model hosts in the absence of chemical stimuli and without "foraging" over the body. Visual aspects of the host such as color, shape, and size appear to be important in the discrimination of host body regions. On quadruped mammals, the body region usually selected is the underside, which is the area lowest in hair density and least accessible to host defensive movements. On artificial hosts painted with white undersides to mimic the color pattern of many natural quadrupeds, fly landing pattern is disrupted.

S15.6.  
6

VISUAL ORIENTATION OF HAEMATOPHAGOUS DIPTERA: AN EVOLUTIONARY PERSPECTIVE.

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Visual receptors in biting flies are one of several sensory systems by which flies find hosts, obtain blood and produce offspring. Natural selection should act on all such systems to maximize fitness. The manner in which selection might shape sensory systems is discussed, emphasizing that 'progressive sensory refinement' is but one of the processes involved. Parasite-host coevolution and competition within and between fly species also shape the evolution of visual host finding behaviour, with consequences as varied as the striping of zebras and the structure of disease vector communities.

P15.-  
1

LABORATORY VECTOR STUDIES ON Aedes albopictus WITH CHIKUNGUNYA VIRUS

YAMANISHI H. (Kobegakuin Women's Junior College 652 Kobe JAPAN) and KONISHI E. (Dept. Med. Zool. Kobe Univ. Kobe 650 JAPAN)

The susceptibility of several mosquito species to chikungunya virus was investigated in oral inoculation. While the virus was detected in Aedes albopictus, Ae. aegypti and Ae. riversi, Culex tritaeniorhynchus, Cx. p. molestus and Cx. fatigans were not infected with the virus. Variation in susceptibility was observed among different geographic strains of Ae. albopictus. Two strains (Hyogo and Oahu strains) with a marked difference in susceptibility were compared in infection rate, growth curves of the virus, dose-response relations and titer distribution. The fluorescent antibody technique was introduced to demonstrating the histological development of the virus.

**P15.-**  
**2** HEMISYNANTHROPIC FLIES AS PROVIDER OF NATURAL PARASITOIDS  
(HYMENOPTERA) FOR THE BIOLOGICAL CONTROL OF EUSYNANTHROPES  
KLAUS FABRITIUS<sup>1</sup> and IONEL ANDRIESCU<sup>2</sup>

<sup>1</sup>Inst.of Hyg.and Publ.Hlth.-Bucharest, <sup>2</sup>Biol.Res.Center-Jassy

The puparia of hemisynanthropic flies Themira putris L. (SEPSIDAE), Physiphora demandata F. (OTITIDAE), Syrirta pipiens L.(SYRPHIDAE) have parasitoides which also occur in Musca domestica L. The paper presents the host-parasite relationships for hemisynanthropic flies, as well as the relations of the parasitoid species with M. domestica. In Romania for instance, Spalangia endius, S. subpunctata, and Urolepis maritima are common for T.putris as well as for M.domestica, whereas Eupteromalus temirae sp.n., Kleidotoma truncata and Phygadeuon pallidicarpus were found only on T.putris. Out of these species, E.temirae was multiplied in the laboratory on puparia of M.domestica, which are readily accepted, thus proving itself as a prospect parasite for the biological control of this species.

**P15.-**  
**3** THE ATTRACTION OF ADULT CHIRONOMIDAE (DIPTERA) TO LIGHT UNDER  
LABORATORY CONDITIONS

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The attraction of 2 pestiferous species of chironomids (Glyptotendipes paripes and Chironomus crassicaudatus) to incandescent light was studied under laboratory conditions. On numerous occasions, field-captured adults of each species held in cages were released from the center of a 9x9 m dark room equipped with 4 New Jersey light traps, one in each corner. To determine the effects of light color, the traps were equipped with combinations of different color (red, orange, yellow, green, blue, and white) 100 watt bulbs. To determine the effect of light intensity, the traps were equipped with combinations of different wattage (25, 40, 60, and 100) white bulbs. Commercially available incandescent bulbs (Gen. Elec., USA) were used. The arrangement of each 4 color or wattage combination in each experiment was randomized. On each occasion, measurements of light intensity were taken for each color or wattage in a combination. Among the combinations studied, the white light attracted the most numbers of adults and red the least; both species exhibited a similar behavior. A significant linear relationship between light intensity and adult catch of a species existed and it seems that the 2 species generally respond to brightness of light rather than any specific color. This behavior of adults of the 2 species could be manipulated in an integrated control program. In relatively uninhabited areas around the midge sources, brighter lights could be used to draw adult populations of the 2 species away from residential and business localities where they pose nuisance and economic problems.



P15.-  
4

MEDICAL AND VETERINARY ENTOMOLOGY - A NEW TEXT

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This poster presents the essential features of a completely new, comprehensive account of the insects and acarines of medical and veterinary importance with emphasis on their roles as pathogens and as vectors of pathogens to man and domestic animals throughout the world.

The focus of medical/veterinary entomology is disease incidence and not primarily the insect or acarine vector. To be effective an entomologist must have a broad understanding of the epidemiology of these diseases, including knowledge of the ecologies of the pathogens and their vertebrate hosts, in order to appreciate the role of the vector. Consequently one third of the text is concerned with a wide range of diseases and pathogens transmitted by insects and acarines.

The entomologist's major contribution will be on the vector and half the text deals with the recognition, biology and bionomics of vectors. A short introduction provides basic information on insects, particularly the Diptera, and contains a chapter on Species Complexes.

Quantitative aspects of epidemiology and vectorial bionomics are stressed throughout, including models of the transmission of malaria and babesiosis.

Section 16 Toxicology .....  
R 16.1. *Effects of Pyrethroids to Insects* .....  
R 16.2. *Methods and Physiological Effects at the Toxicity Test of Insects* .....  
S 16.1. *Membrane Receptors and Enzymes as Targets of Insecticidal Action* .....

**R16.1.** RELATIVE AND RESIDUAL TOXICITY OF SOME  
**1** SYNTHETIC PYRETHROIDS

H.C.L.GUPTA ,R.SINGH, K.L.JAIN AND R.C.SAXENA  
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Toxicity of synthetic pyrethroids against Spodoptera litura larvae by bioassay film method was Decamethrin>Cypermethrin> Fenvalerate>Permethrin> BHC.

Permethrin,Cypermethrin and Fenvalerate at 0.00125,0.0025 and 0.005 per cent were sprayed on gram @ 833 l/ha.Treated samples brought to the laboratory were allowed to feed by reared larvae of Heliothis.Up to seven days all the concentrations gave mortality to the larvae while residual toxicity till 11,15 and 11 days from highest concentration of respective treatments could be recorded.

The seeds of green gram were treated with permethrin,cypermethrin and fenvalerate @ 20,40,60,80 and 100 ppm.Protection to seeds against Callosobruchus till 75 days from 20 to 80 ppm of all the three pyrethroids and till 90 days from 100 ppm of permethrin and fenvalerate , and until 120 days from 100 ppm of cypermethrin was observed.

**R16.1.**  
**2** MODE OF ACTION OF PYRETHROID INSECTICIDES

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Toxicokinetics, competition studies and neurophysiological measurements of the poisoning of house fly, Musca domestica, larvae and adults of either susceptible or kdr strains by pyrethroid insecticides suggest interactions with sodium channels to produce characteristic actions on insects and lead directly to irreversible lesions only when nerve membranes are depolarized for long periods. Nerve-insensitive resistance to pyrethroids has occurred worldwide in pest insects.

## R16.1. PYRETHROID SYNERGISM: MECHANISM AND APPLICATION

3

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<sup>2</sup>Department of Entomological Sciences, University of California, Berkeley, USA

Evidence continues to accumulate that esterases, in addition to oxidases, play a major role in pyrethroid detoxification in insects. In Spodoptera littoralis and Trichoplusia ni larvae, the rate of pyrethroid hydrolysis is higher with the trans- than with the cis-isomers, correlating with their relative insecticidal activities. Under laboratory conditions, the toxicity of cis-cypermethrin is synergized by profenofos considerably against T. ni and S. littoralis. Under glasshouse conditions, profenofos, monocrotophos and methidathion synergize the toxicity of cypermethrin over 20-fold against the whitefly Bemisia tabaci. On the other hand, in larvae of Tribolium castaneum and Musca domestica vicina, oxidase inhibitors such as piperonyl butoxide and Niagara 16824 synergize the toxicity of several pyrethroids. Apparently the predominant pathway of pyrethroid detoxification, whether hydrolytic or oxidative, depends largely on the insect species involved.

A search for pyrethroid synergists with low mammalian toxicity reveals that the organophosphorus compounds acephate, azamethiphos and methacrifos may serve as potential synergists in S. littoralis and the juvenoid compound R0 13-5223, as synergist in T. castaneum and M. domestica vicina. Structural optimization of pyrethroid esterase and oxidase inhibitors may lead to new and useful synergists acting preferentially in insects as compared with mammals.

## R16.1. STUDIES OF ORGANOPHOSPHORUS AND PYRETHROID RESISTANCES

4

IN THE DIAMONDBACK MOTH, PLUTELLA XYLOSTELLA L.

EDWARD Y. CHENG

Dept. Applied Zoology, TARI, Taichung, Taiwan, R.O.C.

Several insecticide resistance mechanisms reported in other insects in relation to the organophosphorus and pyrethroid insecticides have been investigated in the diamondback moth, Plutella xylostella L. The organophosphorus and pyrethroid resistant strains were obtained from a common susceptible IL-strain by crossing the parental strain with a designated insecticide individually. The differences between the susceptible and the resistant strains in relation to important organophosphorus and pyrethroid resistance mechanisms will be discussed in detail. The mechanisms studied were cholinesterases, carboxylesterase, mixed-function oxidases, glutathione-S-transferase and several other detoxication enzymes.

## **R16.1.** PHAGOSTIMULANTS ENHANCING THE TOXICITY OF PYRETHROIDS FOR LARVAE OF **5** *SPODOPTERA LITTORALIS*

J. MEISNER and K.R.S. ASCHER

Department of Toxicology, The Volcani Center, Agricultural Research Organization, Bet Dagan, Israel

The effect of the two commercial phagostimulants Coax and Gustol on the feeding rate of Spodoptera littoralis Boisduval was investigated in the laboratory by offering to the larvae treated lamellae of Styropor (foamed polystyrene) or treated leaves of hostplants. 1% Coax or Gustol treated lamellae were consumed by the larvae at about the same rate as 1% sucrose, whereas the feeding of the hostplant was not enhanced by the addition of the phagostimulants.

The toxicity of cypermethrin and deltamethrin + Coax or Gustol was investigated in the laboratory by offering treated lucerne to larvae of S. littoralis. When 0.02-0.1% Coax was added to cypermethrin and 0.05%-0.1% to deltamethrin, toxicity was significantly higher at all ratios tested. No activity was found with 0.1% of Gustol.

## **R16.2.** ON THE SIGNIFICANCE OF THE EPICUTICULAR WAX LAYER IN STUDIES OF **1** PHARMACOKINETICS OF INSECTICIDES IN INSECTS.

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Studies of pharmacokinetics of insecticides form an important aspect of research in insect toxicology. These studies provide quantitative and qualitative information about the fate of administered chemical from the site of application to the target site. In most experiments insects are treated topically. The applied insecticide spreads all over the body of an insect principally through the epicuticular wax layer. Lateral spread of insecticides is, therefore, a key factor in the process of penetration through the cuticle of treated insects.

The cuticular surface of insects over which there is a continuous spread and loss of waterproofing lipids is expected to contain several exocuticular enzymes and provide suitable environment for a range of microorganisms. Thus the epicuticular wax layer of insects may play an important role in the metabolism (activation or inactivation) of topically applied insecticides. The results of some recent studies carried out by the author indicate that, in insects, a topically applied insecticide may be broken down in the epicuticular wax layer, the metabolism of insecticides in the external lipid layer may be qualitatively different from that occurring in rest of the insect body. Microorganisms which inhabit the external surface of insects may contribute to qualitative differences observed in the general body and epicuticular metabolism of topically applied insecticides.

## 16.2. BIOGRAMS OF HPLC-FRACTIONATED TOXIC COMPOUNDS

2

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Microtests were developed to assay toxic substances which were fractionated on High Performance Liquid Chromatography (HPLC). As a model substance, Antimycin was fractionated on a hydrophobic column. The cytotoxicity of the fractions was evaluated using an *Aedes aegypti* cell line, and was compared to the toxicity of the same fractions to *Aedes* larvae. The versatility of this set of techniques was also investigated by identifying known ingredients of black pepper.

## 16.2. BENZYL-1,3-BENZODIOXOLE CHEMOSTERILANTS : PHYSIOLOGICAL AND BIOCHEMICAL INDICATIONS FOR ANTI-JH ACTION

3

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We have investigated the mode of action of benzyl-1,3-benzodioxoles, reported as non mutagenic insect chemosterilants. Physiological observations indicate an anti-JH effect. In *Sarcophaga bullata* benzyl-1,3-benzodioxoles affect the sequestration of vitellogenin into the ovary, a process reported to be under JH control.

In a modified *Galleria* wax test the typical reaction of *Galleria* pupae to JH is strongly inhibited. Adding benzyl-1,3-benzodioxoles to *Musca domestica* larval medium results in larval death and deformed unviable pupae. Only partial rescue with JH analogue ZR 515 was possible.

We have now demonstrated a JH binding protein in *Sarcophaga* ovaries. Results of our recent research towards a possible interaction of benzyl-1,3-benzodioxoles with the JH binding protein will be reported.

**R16.2.** EFFECT OF THE ANTIBIOTICA CHARTREUSIN ON EPILACHNA  
**4** VARIVESTIS Muls. (COL. COCCINELLIDAE)

H. Holst<sup>1</sup> and U. Schlüter<sup>2</sup>

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The antibiotic Chartreusin leads to a strong disturbance of metamorphosis in *E. varivestis*. A 0.2% solution of Chartreusin sprayed on bean plants prevents in 30% of 3rd-instar larvae the next molt. These larvae show no external defects. From those who succeed in molting to the 4th-instar only about 8% are able to continue metamorphosis and finally reach the adult stage. In most individuals, metamorphosis is interrupted during the pupal stage. Some individuals develop into adultoid forms with heavy wing damages. Besides disturbances during metamorphosis, individuals treated as 4th-instar larvae often develop black spots in the thoracic region. These were examined by histology and proved to be accumulations of material of hitherto unknown origin. The spots are situated between the cuticle and the underlying evaginated wing disks.

**R16.2.** BEHAVIOURAL AND PHYSIOLOGICAL SYMPTOMS INDUCED BY THE NOVEL  
**5** INSECTICIDE SN 72 129

H. C. VON KEYSERLINGK

Schering AG Pflanzenschutz, Gollanczstr. 57-101, D 1000 Berlin 28

The molecular structure of this novel insecticidal compound will be outlined. The feeding and locomotor behaviour of *Musca domestica*, *Leptinotarsa decemlineata* and *Heliothis virescens* has been investigated when exposing the untreated insects to contaminated food plants. The process of intoxication between topical treatment with 2 x LD<sub>50</sub> doses and death will be described in terms of behavioural and physiological symptoms. The effects on skeleton muscles and visceral organs on the peripheral and central nervous system on axonal and synaptic transmission will be described as well as the effect of selected synergists. The most vulnerable physiological process will tentatively be identified.

**R16.2.** SELECTIVITY OF AN ORGANOPHOSPHOROUS INSECTICIDE(TIA-230) AMONG INSECT  
**6** SPECIES AND NON-SPECIFIC ESTERASES(AliE)

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Insecticidal activity of TIA-230, O-[1-(4-chlorophenyl)-4-pyrazolyl] O-ethyl S-propyl phosphorotiolate, and synergistic action of IBP with it were tested in five insect species, *Spodoptera litura*, *Plutella xylostella*, *Henosepilachna vigintioctopunctata*, *Laodelphax striatellus* and *Nephotettix cincticeps*.

Inhibition of AliE isolated electrophoretically from the insects, by TIA-230 and IBP was also measured. Synergistic action of IBP with TIA-230 was observed in less susceptible species(*H. vigintioctopunctata*, *L. striatellus*, *N. cincticeps*), and the synergism correlated well with AliE inhibition by IBP. In susceptible species(*S. litura*, *P. xylostella*), both synergistic action and AliE inhibition by IBP were very weak. In *N. cincticeps*, the least susceptible species, activity of all AliE bands were strongly inhibited by TIA-230 in vitro. This shows the strong affinity of the esterase to TIA-230 and the large capacity to conjugate with it, which might be the cause of the tolerance of this species to TIA-230.

**R16.2.** EFFECT OF DIFFERENT TEMPERATURES AND ITS DURATION ON THE  
**7** EFFECTIVITY OF REPELLENT-FIXATIVE FORMULATION TO THE  
WORKERS OF APIS FLOREA F. IN LABORATORY CONDITIONS

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Laboratory experiments were designed at three temperatures (25, 30, 35°C) exclusively at first for candidate compounds and then for repellent-chemical fixative mixtures. o-Amino acetophenone and Ethyl benzyl ketone were tested with four fixatives (Benzophenone, Diethyl phthallate, Benzyl alcohol and Benzyl benzoate) in six different proportions of each. The repellent-fixative ratio is an important parameter in determining the duration of effectivity of repellents. Equal proportion of repellent-chemical fixative (1:1) ratio is an appropriate formulation of each repellent tested. The effectivity was maintained for a longer duration at 25°C and for a shorter duration at 30°C and 35°C. The duration of effectivity varied from one chemical-fixative to another. o-Amino acetophenone and Benzophenone (1:1) maintained effectivity for 8 h as compared to Diethyl phthallate (1:1) 6 h, Benzyl alcohol (1:1) 6 h and Benzyl benzoate (1:1) 6 h at 25°C if 70 per cent repellency was taken as the acceptability level. The proportion of repellent-chemical fixative in mixture is the determinant factor in enhancing the duration of repellent function under given thermal conditions.



**R16.2.** THE EFFECT OF DIETARY METHYLMERCURY FOR THE ACTIVITY OF  
8 ADULT MEALWORMS (TENEbrio MOLITOR L.)

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A naivistic view holds that each poison causes specific symptoms of disease. These symptoms occur, however, only in cases of massive poison contamination. In environmental pollution poisonings of this degree occur only rarely, but widely occurring poison contaminations of low degree are common. Numerous examples indicate that the later have severely deteriorating -though hidden - physiological, ecological and public health effects. Wery little is known about such hidden effects in insects.

It is possible to contaminate adult mealworms with mercury to a high degree without causing clear disease symptoms (P.& S-L, Nuorteva, Ambio 11:34-37, 1982) by feeding them with mercury loaded flies. We composed a test, where we simultaneously followed the activity of two groups of adult mealworms. One group was fed with flies containing 91-112 ppm Hg, the other with normal flies (0.3-0.7 ppm Hg). During the experiment the mercury level in the control group rose up to 8.2 ppm and in the other group to exceed 250 ppm. During the 2-3 first weeks there was no significant difference in the activity of the two groups, but later the group feeding on heavily mercury loaded flies showed significantly and consistently lower activity, although no visible cahnge in their health could be seen until after 11 weeks (then the animals on the high-mercury diet lost their ability to come on their feet if placed on the back).

**R16.2.** PERSISTANCE OF SOME PESTICIDES IN SOIL AND THEIR EFFECT  
9 ON THE EXISTING ARTHROPODES IN TWO SOIL LAYERS.

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The selected area is a turf plot located in New Brunswick,N.J., U.S.A. Determination of pesticides, their residues and the occurring arthropodes were evaluated at two soil depths,(0-2"& 2-4"). The chosen compounds were : chlorpyrifos,chlordane and DDT.

For the determination of the chosen pesticides, concentrated extract was prepared after,(Biedman,1978). Chlordane content was estimated by two methods :CGC,(Thompson,1970) and DS after (Ordas,1956). DDT and its metabolites were determined by EC-GC, (Watt,1980),while chlorpyrifos determination was by using FPD in phosphorus mode.

Results indicated an up-set in the vertical distribution of soil arthropodes after dursban application. The authers suggest that the longivity of pesticide would be 90-100 days. Chlordane residues were found to exist in soil for about 20 years, and it is recommended to use the Ordas method. The DDT residues were found to exist in soil for 16 years ,(DDT & DDE < 0.1ppm).

16.1.  
1 Identification of the Neurotoxin released by DDT-prostrate  
Cockroaches (*Periplaneta americana*) and DDT Induction  
of Tyrosine Decarboxylase.  
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The toxic substance in the haemolymph of DDT-prostrate cockroaches (*Periplaneta americana*) has been tentatively identified as tyramine, the decarboxylated product of tyrosine, by paper chromatography and HPLC. The tyramine is presumed to arise from the action of tyrosine decarboxylase on tyrosine. Tyrosine decarboxylase activity was detected mainly in the nerve cord but also in the haemolymph of the cockroaches. *In vivo*, treatment of cockroaches with DDT induced tyrosine decarboxylase activity approximately twofold, and the induction was accompanied by an increase of cAMP. Control for the induction process was at the transcriptional level, and was completely abolished on treatment of cockroaches with actinomycin (0.1 ug/ insect). Based on the fact that continuous electrical stimulation and treatment with three neurotoxic insecticides causing extreme excitation all caused the production of the neurotoxin, a theory of enzyme induction by physical agents (electrical stimulation) is proposed. Tyramine is in part converted to octopamine by  $\beta$ -hydroxylation, and in part undergoes oxidative deamination to inactive  $\beta$ -hydroxymandelic acid.

16.1.  
2 THE EFFECT OF INSECTICIDES ON CALCIUM REGULATORY SYSTEMS

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Of the two mechanisms which return intracellular calcium to its resting level after stimulation (e.g. ATP-driven Ca pump and Na-Ca exchange), the Na-Ca countertransport mechanism is assumed to be the more dominant due to the rapid and large increase in its rate of operation (i.e. 300-fold increase) apparent as intracellular calcium concentration increases.

The Na-Ca exchanger was examined in axolemma and synaptolemma membranes and was found to be similar to Na-Ca exchange in cardiac muscle in that it appears to be regulated by a phosphorylation-dephosphorylation process which is mediated by a Ca/calmodulin interaction. Also, this ATP-modulated aspect of the Na-Ca exchanger has many similarities with the Na-Ca stimulated ATP hydrolyzing activity originally reported by this author which was found to be highly sensitive to the action of DDT and some pyrethroid insecticides.

The action of these insecticides on this exchange were then correlated to their action on the (K-depolarisation)-dependent release of norepinephrine from intact synaptosomes which is a well characterized calcium-dependent event.

S16.1.  
3

THE NICOTINIC ACETYLCHOLINE RECEPTOR: MOLECULAR ASPECTS AND INTERACTIONS WITH INSECTICIDES.

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The nicotinic acetylcholine receptor is activated by agonists which bind to "receptor sites" causing opening of its ionic channel through which cations flux. It is inhibited by competitive antagonists (e.g.,  $\alpha$ -bungarotoxin) that bind to the receptor sites and noncompetitive antagonists (e.g., perhydropyridostigmine (H<sub>12</sub>-HTX)) that bind to its "channel sites". The receptor also undergoes desensitization as a result of binding of ligands to either of the two kinds of sites. Nicotine activates the receptor by binding to the receptor sites and inhibits it by desensitization and binding to the channel sites, while lobeline acts only as a noncompetitive antagonist. Increasing the chain length of a homologous series of symmetrically substituted tetraalkylammonium anticholinesterases, from tetramethyl to tetrahexyl, decreases affinity for the receptor sites and increases it for the channel sites. The carbamates neostigmine and pyridostigmine are mainly partial agonists, while physostigmine is a noncompetitive antagonist which binds to the receptor's open channel conformation. Pyrethroids modulate receptor function by binding to a third kind of site. Also, on the agonist activated receptor, they inhibit [<sup>3</sup>H]H<sub>12</sub>-HTX binding to the channel sites, with higher potencies at lower temperatures. The actions of insecticides on vertebrate peripheral nicotinic receptors are compared with those of housefly brain. (Supported by NIH grant No. ES02594).

S16.1.  
4

BRIDGED BICYCLIC ORGANOPHOSPHORUS COMPOUNDS AS A PROBE FOR TOXICOLOGICAL STUDY ON GABA SYNAPSE.

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Bridged bicyclic organophosphorus compounds (BPs) with appropriate substituents show high toxicity although they are not potent acetylcholinesterase inhibitors. Some BP analogs were synthesized to elucidate the mode of action of the compounds. It was electrophysiologically shown that the BPs act as gamma-aminobutyric acid (GABA) antagonists. Ligand-receptor binding studies indicated that there is a specific binding site for the BPs in the nervous system related to the GABA synapse. The BP binding to the site disturbs the function of the GABA synapse. The structure and nature of the binding site were speculated by use of macrocyclic compounds as a model. Structure-toxicity relationship studies showed different profile between insects and mammals, suggesting the possibility that the structure and nature of the BP binding site in the insect may be different from those in the mammal. The BPs are suitable as a tool for the toxicological study on the insect GABA synapse.

## S16.1. THE EFFECTS OF INSECTICIDES ON NEUROSECRETORY PROCESSES IN INSECTS

6

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Neurosecretory cells are modified for glandular activity and yet have maintained all of the electrical properties of 'ordinary' neurons. Since many insecticides are believed to act primarily upon the nervous system by modifying electrical properties, it is apparent that neurosecretory cells should be considered as a possible target site for insecticides. In addition neurosecretory cells are endowed with large areas of membrane lying outside of the blood-brain barrier (neurohaemal areas) and as such are readily accessible to xenobiotics that enter the haemolymph.

This presentation will review the evidence which has accumulated over recent years for insecticide-induced alterations in neurosecretory activity. As will be shown, a variety of insecticides induce changes in ultrastructure, electrical activity and hormonal output of neurosecretory cells. The possibility that neurosecretory cells are more susceptible than other neurons to insecticides will be discussed.

## S16.1. THE GABA-RELATED SYSTEMS AS THE TARGET OF INSECTICIDE ACTIONS

7

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The nature of the picrotoxinin-receptor was studied in the central nervous system (CNS) of the American cockroach. First, it was confirmed by using an electrophysiological technique that the abdominal nerve cord of the American cockroach is sensitive to picrotoxinin. By using a [<sup>3</sup>H]α-dihydro-picrotoxinin binding test it was determined that the picrotoxinin receptor in CNS of this insect has a higher affinity toward picrotoxinin and heptachlor epoxide than the corresponding receptor in the rat brain. Also, the cockroach brain preparation has a higher percentage of specific binding, making this material suitable for receptor studies. The receptor shows sensitivity to all insecticidal cyclodienes tested, namely photodieldrin, oxychlordan, endrin, heptachlorepoxyde, r-chlordane, dieldrin, aldrin, heptachlor and isodrin (expressed in the order of potency). Among four BHC isomers, only the gamma-isomer shows a significant potency to bind with this receptor. Studies on cyclodiene resistant German cockroaches, Aedes aegypti larvae and houseflies showed that all resistant insects have reduced binding capabilities to [<sup>3</sup>H]α-dihydropicrotoxinin. These results clearly indicate that the picrotoxin receptor is the main target of cyclodiene insecticides.

16

**S16.1.** ACTIONS OF PESTICIDES ON PROCESSES MEDIATED BY  
**8** CYCLIC AMP AND PROTEIN PHOSPHORYLATION IN INSECTS

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Cyclic AMP, produced through activation of the membrane-bound enzyme, adenylylate cyclase, mediates the intracellular actions of a number of vertebrate and invertebrate neurotransmitters and neurohormones. Recently, evidence from this and other laboratories has established that the formamidine pesticides are potent activators of adenylylate cyclase in insect nerve tissue and are functional analogs of the amine neurohormone, octopamine. In the present work, a number of insecticides were examined for their actions on insect adenylylate cyclase. Special solvent systems were devised to allow solubilization of the compounds while maintaining enzyme activity. Among a number of compounds studied, chlorpyrifos and Dinocap were found to be direct inhibitors of enzyme catalytic activity while DDT, dieldrin, and rotenone were antagonists of hormone-stimulated activity. Although none of these compounds stimulated enzyme activity, several new cyclic amidine derivatives tested were found to be potent activators of octopamine-sensitive adenylylate cyclase.

**S16.1.** THE EFFECT OF AVERMECTINS ON INVERTEBRATES GABA NERVOUS SYSTEMS  
**10**

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The avermectins are a family of structurally-related macrolide disaccharides in the mycelia of Streptomyces avermitilis. They possess potent anthelmintic and insecticidal activities by immobilizing the nematodes, insects, crustaceans etc. The mechanisms of action of one of the derivatives avermectin B<sub>1a</sub> (AVM) have been investigated. It has little effect on the neuromuscular junction of the nematode Ascaris suum, but demonstrates inhibition of signal transmission from the central command interneurons to the peripheral motoneurons of Ascaris. This inhibition can be reversed by picrotoxin, a blocker of chloride ion channels. Similar inhibitory effects can be mimicked by applying GABA or muscimol, a GABA agonist, to the interneurons of Ascaris; suggesting that AVM may act as a GABA agonist. On the arthropods, AVM paralyzes Daphnia magna which can be also reversed by picrotoxin. Application of AVM to the lobster's stretch muscle causes a rapid elimination of IPSP followed by a gradual disappearance of EPSP, due to loss of muscle membrane resistance reversible by picrotoxin. The action potential of crayfish stretch receptor is also blocked by AVM which is again reversible by picrotoxin.

It is thus concluded that AVM acts by opening the Cl<sup>-</sup> channels in postsynaptic membranes. Further studies with mammalian brain membranes have indicated a specific AVM binding site in the GABA receptor - Cl<sup>-</sup> channel complex. Binding of AVM enhances binding of GABA and stimulates presynaptic release of GABA, both lead to opening of Cl<sup>-</sup> channels.

**516.1.** RADIOTRACER STUDIES OF MEASURING THE UPTAKE OF DIMETHOATE  
**12** ON THE ARTIFICIAL DIET BY MYZUS PERSICAE (SUIZ.).

IRAJ JAVADI (Ph.D.) Assistant Professor, School of Pharmacy,  
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A review of the literature showed that little work had been done on the toxicity of systemic insecticides as stomach poisons to aphids. An artificial method of feeding the aphid Myzus persicae (Sulzer) was employed to study these problems, using sucrose solutions labelled with the isotope  $^{14}\text{C}$  enclosed in 'Parafilm' membranes as the source of food. The radiotracer technique showed that systemic insecticide dimethoate was feeding deterrent for M.persicae and the uptake of sucrose containing 1,10,100 and 1000 ppm dimethoate was 5,9,15 and 73 times less respectively than uptake of non-insecticidal sucrose.

**P16.-** RECENT ADVANCES IN THE MODE OF ACTION OF CYCLODIENE INSECTICIDES.  
**1**

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Despite their discontinued application in agriculture in many developed countries cyclodiene insecticides continue to intrigue toxicologists because of their complex mode of action and development of resistant insect species. Though the precise mechanism of action of cyclodiene compounds still remains obscure, considerable efforts have been made to characterize their effects upon the nervous system using dieldrin and its derivatives as representatives of this class of chemicals. Many investigators have suggested that, before it exerts its action, dieldrin is metabolised to trans-aldrindiol in the nervous system. Recently, however, the identity of trans-aldrindiol as the neurotoxic form of dieldrin has been questioned. There is growing evidence which indicates that the characteristics of the action of dieldrin and trans-aldrindiol upon the nervous system may be different. Results of some recent studies carried out by the author indicate that dieldrin destroys cellular organelles critically involved in transmitter synthesis and storage by increasing the uptake of  $\text{Ca}^{2+}$  by presynaptic terminals of cholinergic synapses. Cyclodiene-induced increased uptake of  $\text{Ca}^{2+}$  by nerve terminals may occur independent of depolarization. On the other hand, the action of trans-aldrindiol upon the nervous system does not appear to be mediated by increased  $\text{Ca}^{2+}$  uptake but related to a shift in ionic permeability eventually leading to membrane depolarization. It is possible, therefore, that the site and mechanism of action of dieldrin and trans-aldrindiol upon the nervous system may be different. Recently it has been suggested that the binding site of dieldrin, in insect nervous system, may be the picROTOXININ receptor.



Section 17    Side Effects of Pesticides and Resistance of  
                  Arthropods to Pesticides.....

R 17.1.    *Side Effects of Pesticides on Arthropods* .....

S 17.1.    *Resistance of Arthropods to Pesticides* .....

P 17.       .....



**R17.1.** ACTIVITIES BY THE IOBC/WPRS WORKING GROUP "PESTICIDES AND  
**1** BENEFICIAL ARTHROPODS": DEVELOPMENT OF STANDARDIZED TESTS

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The Working Group "Pesticides and Beneficial Arthropods" of the International Organization for Biological Control (IOBC), West Palearctic Regional Section (WPRS) attempts to develop a standard procedure to test the side effects of pesticides on beneficial organisms that includes laboratory, semi-field and field test methods. Standard characteristics of test methods, choice of beneficial organisms, integrated test procedure as well as results of joint testing programmes including 60 pesticides, about 15 beneficial arthropods and entomopathogenic fungi are summarized in this work.

**R17.1.** A PROCEDURE FOR TESTING SIDE-EFFECTS OF PESTICIDES ON THE PREDATOR  
**2** Chrysoperla carnea STEPH.

F. BIGLER<sup>1</sup>, F. SHANIN<sup>2</sup> S.A. HASSAN<sup>2</sup>: <sup>1</sup>Swiss Federal Research Station for Agronomy, CH-8046 Zurich, <sup>2</sup>Institute for biological pest control, D-6100 Darmstadt  
The polyphagous predator, Chrysoperla carnea Steph. is one of the beneficial insects which has been chosen by the IOBC/WPRS working group "Pesticides and beneficial arthropods" to develop an integrated testing scheme. Thereby not only mortality but also the beneficial capacity (e.g. food intake and fecundity/fertility) are the parameters assessed. A laboratory method which allows the measurement of the initial toxicity of pesticides to larvae of this predator has been developed and more than one hundred different chemicals have been tested up to now. Compounds, showing a reduction of the beneficial capacity of less than 50 % are considered as harmless and their effects are not assessed any further. Pesticides which do not prove harmlessness in the laboratory are further tested on plants under semi-field conditions. Those chemicals, being harmful in this test, are subjected to a field test which provides conclusive information.

**R17.1.** A SEQUENTIAL LABORATORY TEST SYSTEM ASSESSING PESTICIDE COMPATIBILITY  
**3** WITH BIOLOGICAL CONTROL BY ENCARSIA FORMOSA

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Pesticides used in systems of integrated control need to be harmless to the biological control agent. Laboratory test methods are particularly suited to establish harmlessness to beneficial arthropods. A sequential system of tests was developed according to IOBC-guidelines (Working Group: Pesticides and Beneficial Arthropods) in order to reliably predict the harmlessness, i.e. the compatibility of pesticides with biological control of whitefly by Encarsia formosa under glass. Initially a pesticide is tested on the E. formosa adults (most sensitive stage) by measuring the capacity for parasitizing white fly after exposure to a fresh residue on glass during a standardized period. Lack of effect is interpreted principally as harmlessness. Pesticides significantly reducing parasitization are then tested by direct spraying the pupae (least sensitive stage). Pesticides killing most of the pupae are classified as harmful. Pesticides harmful to adults but harmless to pupae may or may not be sufficiently persistent to kill the adults emerging from the surviving pupae. This is verified in a test where young adults are exposed to an aged residue on leaf after which the survival is measured. Persistent pesticides then are classified as harmful; non-persistent ones as possibly harmful. Only harmfulness as a conclusion from the sequential test system need be confirmed by a field test since laboratory tests can establish positively only harmlessness. Conclusions from the sequential system up till now are in full agreement with available field experience for all pesticides studied.

**R17.1.** STANDARDIZED METHODS FOR TESTING THE SIDE EFFECTS  
**4** OF PESTICIDES ON PREDATORY MITES

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Various methods for testing side effects of pesticides on phytoseiid mites have been developed by members of the IOBC/WPRS Working Group "Pesticides and Beneficial Arthropods".

In the specific laboratory tests the initial toxicity of the pesticide is determined with respect to mortality and possible effect on reproduction. A total effect of less than 50 % is considered harmless. The pesticides are applied (at the field concentration) to either a glass substrate or to detached bean leaves on wet cotton wool.

A semi-field test has been developed for Phytoseiulus persimilis whereby the mites are placed on treated bean plants. In field tests on orchard mites, mite numbers present in samples of leaves from treated cherry trees are compared with figures for untreated trees.

**R17.1.** A STANDARD METHOD TO TEST SIDE EFFECTS OF PESTICIDES ON PRADACIOUS  
**5** MITES IN VINEYARDS

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Pradacious mites can play an important role as natural ennemies of spider mites. Pesticides are harmful or harmless for pradacious mites. To establish integrated control programs, side effects on beneficials should be taken in consideration. A method is described, which allows to test side effects of fungicides, insecticides and acaricides on predatory mites in vineyards. The experimental conditions, the application of treatments and the mode of assessment, the recording an measurements are explained. Some results are presented and the strategy of an integrated mite control program is discussed.

**R17.1.** EFFECT OF PESTICIDE INTERACTIONS ON THE TWOSPOTTED SPIDER MITE  
**6** TETRANYCHUS URTICAE KOCH ON PEANUTS.

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University, P.O. Box 5215, Raleigh, NC 27650 USA

The twospotted spider mite occurs frequently in outbreak numbers on peanuts, especially following periods of dry weather. Investigation of factors that may cause outbreaks showed there was a relationship between pesticides and interactions of pesticides on mite buildup and mite damage.

Insecticides caused mite increases but some fungicides caused a more severe long term adverse effect than insecticides. There was a wide range among fungicides in their interaction effect on mite buildup. Some fungicides did not create a mite outbreak. When fungicides were combined with insecticides the mite problem usually increased. Combinations of pesticides and sequences of pesticides all created a differential effect on increases of spider mites.

Information will be presented on the effect of insecticides, fungicides, herbicides, growth regulator, combinations, sequences and tank mixes on mite increases as well as possible reasons for mite outbreaks.

**R17.1.** IMPACT OF FOUR SYNTHETIC PYRETHROIDS ON *Amblyseius fallacis* AND  
7 THEIR RESIDUE LEVELS ON APPLE FOLIAGE.

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CANADA

The toxic effects of cypermethrin 12.5WP, 20WP, permethrin 25WP and fenvalerate 30EC to *Amblyseius fallacis* was determined when these predaceous mites were exposed in the laboratory to apple foliage treated in the orchard with these compounds for plant bug control. The results indicated<sup>that</sup> when these compounds were applied at petal fall, these products remained toxic to these mites for at least 45 days. Gas chromatographic analyses of leaves collected at different intervals of time after treatment showed a sharp decline in residue levels about 2 weeks after treatment, then the degradation rate decreased. Nevertheless, residue levels about 10% of the amount detected on zero day, were detected 124 days after treatment.

**R17.1.** COMPARATIVE TOXICITY OF SOME INSECTICIDES TO THE BENEFICIAL  
8 COMPLEX OF COTTON IN EGYPT, BRAZIL AND USA.

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Three types of insecticides, the benzoylphenylurea CGA 112913 (IKI-7899), chlordimeform and various pyrethroids such as high-cis cypermethrin, decamethrin or permethrin were applied straight or in mixture over a two-year period to cotton in Egypt, Brazil and the USA. The impact of the treatments on the beneficial complex was measured at regular intervals during the growing seasons. All pyrethroids at rates of between 8 and 30 g a.i./ha proved to be detrimental to all beneficial groups except to neuropterous larvae and Mirid nymphs. Chlordimeform at 250 g a.i. was quite safe to all groups of beneficials. CGA 112913 was safe to all adult stages at the dosage range between 60 and 250 g a.i.. It reduced the numbers of juvenile stages of *Orius* spp. and Mirids in Egypt when used at a rate of 250 g a.i., but either had no effect or the numbers were only depressed for a short time when it was used at between 60 and 125 g a.i. in all three countries. The findings of this research suggest that chlordimeform and CGA 112913 can be used safely in cotton IPM programs.

**R17.1.** INVESTIGATIONS OF SELECT INSECT TAXA FOR PENTACHLOROPHENOL  
**9** (PCP) TAKEN FROM THE GROUND LITTER OF 2 FOREST BIOTOPES

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Surveys to determine the arthropod fauna have been made in the Burgholz Forest (Bergisches Land, W.-Germany) since 01.04.1978 by means of ground and arboreal photoeclectors. The biotopes under survey were a beech forest and a spruce-fir forest. Special consideration is given to 3 insect taxa, i.e. coleoptera, nematocera and collembola. Their spectrum of species was largely determined.

In order to trace indicator organisms open areas in the biotopes, which were previously contaminated with PCP, have been examined for the arthropod compound since 14.03.1983. In addition soil specimens were examined in the laboratory, too. The trapping devise employed in the open land were ground photoeclectors and in addition so-called laboratory eclectors. The latter are mainly used to catch nematocera. Apart from that the collembola are collected from soil specimens obtained by means of a modified MacFadyen extractor.

**R17.1.** DIFFERENTIAL SUSCEPTIBILITY TO DDT AND FENITROTHION CAUSED BY PARASITIZATION OF LARVAE OF *PAROPSIS ATOMARIA* OLIVIER (COLEOPTERA: CHRYSOMELIDAE)  
**10**

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Fourth (final) instar larvae of the eucalypt-defoliating beetle *Paropsis atomaria* Ol. frequently were parasitized by tachinid flies (*Froggattimyia* spp. or *Paropsivora* spp.) and the braconid hymenopteron *Eadya paropsidis* Huddleston and Short. Larvae showed heterogeneity of response to DDT and fenitrothion, caused by this parasitization. Separate analyses for larvae parasitized by *Eadya*, parasitized by tachinids and non-parasitized, indicated homogeneous response within these groups. For DDT,  $LC_{50}$  of 0.047% w/v for parasitized larvae was significantly less than the 0.066% for non-parasitized larvae. Parasitized larvae containing *Eadya* were more susceptible ( $LC_{50}$  of 0.043%) than those containing tachinids ( $LC_{50}$  of 0.06%). For fenitrothion,  $LC_{50}$  was 0.0033% for parasitized larvae, significantly less than the 0.0045% for non-parasitized. Larvae parasitized by *Eadya* again were more susceptible ( $LC_{50}$  of 0.0031%) than larvae containing tachinids ( $LC_{50}$  of 0.0038%).

Reasons for, and effect of, this different susceptibility are discussed.

## **R17.1.** CHANGES IN BEHAVIOUR REACTIONS OF ISOPODS ON PESTICIDES **11**

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Applications of pesticides in agricultural systems can bring about several side effects on "non-target-organisms". Even in the sublethal range reactions of behaviour can be changed in such a manner that interspecific and intraspecific concurrence are influenced directly and indirectly, so that the original steady-state can lose its stability. This phenomenon will be demonstrated with examples on the isopod species *Oniscus asellus* LINNE 1758.

## **S17.1.** RECENT RESEARCH INTO RESISTANCE TO PYRETHROID INSECTICIDES **1**

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The recent development of resistance to pyrethroid insecticides in the housefly (*Musca domestica* L.) on animal farms in the U.K. has been investigated both in the field and in the laboratory. The results of this research which includes the ecology, population dynamics, qualitative and quantitative genetics and some biochemical studies of pyrethroid resistance in houseflies will be presented and discussed.

517.1.  
2

## MALATHION RESISTANCE OF GREEN PEACH APHID IN TAIWAN

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Biochemistry and genetics of malathion resistance in Myzus persicae (Sulzer), have been studied for last two years in central area of Taiwan. Sixteen parthenogenic clones were established by starting from isofemales collected on 6 different host plants. Levels of malathion resistance range from 2.95 to 20.6 mg/ml in LD50. Aphids with red color polymorphism were generally more resistant than green and yellow ones. Esterase-4 activity, which has been strongly correlated with the resistance to various kinds of insecticide in this insect by British scientists, was found not important to malathion resistance here. The correlation between total esterase activity and the resistance, however, is still significant. Other esterases which detoxify malathion non-specifically seem more important in this case. Among them, Esterase-2 and -3 occur mutual-exclusively, probably indicating the regulation of two isozymes by a same gene locus. Percent of individuals with high total esterase activity increased in the field populations as the adverse environmental period of rainfall season approached. Translocations between chromosome I and III occur in all green peach aphids examined. This excludes the possible correlation between chromosome aberration and malathion resistance in Taiwan. We believe that the chromosome translocation in this aphid probably has other evolutionary/adaptive significance. Artificial induction of holocycles has never been succeeded in our trials.

517.1.  
3

## DIAGNOSIS OF INSECTICIDE-RESISTANCE IN APHIDS

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The response of different field populations of PHORODON HUMULI SCHRK. to organophosphorus and carbamate insecticides was tested by a leaf-dip bioassay and compared with the levels of carboxyl-esterase activity. As supplementary information, the proportion of resistant and susceptible individuals of the heterogeneous field populations was determined by evaluating frequency distribution curves of esterase activity. Also, the inheritance of esterase activity was tested as an indicator of the stability of resistance in the progenies of single aphids.

Furthermore an attempt was made to use another biochemical technique for routine determination of insecticide resistance. For this purpose, the hydrolysing capacity of homogenates of s and r aphids (MYZUS PERSICAE SULZ., PHORODON HUMULI SCHRK.) to OP-compounds was compared.

**S17.1.** THE OCCURRENCE OF THE KDR-FACTOR IN HOUSEFLIES AND THE POTENTIAL  
**4** RESISTANCE TO PYRETHROIDS IN DENMARK AND ELSEWHERE.

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R = resistance

The kdr-factor is an R-mechanism for DDT and analogues and for pyrethroids, by lowering the sensitivity of the insect nerves. Kdr may be diagnosed by tests with DDT + synergists that inhibit detoxication of DDT.

Heterogeneous high DDT-R seems to persist in most populations of houseflies, Musca domestica, in the world. Early and recent extensive R-surveys on farms indicate that this DDT-R is mainly due to the kdr-factor in Denmark and other parts of Scandinavia, and kdr was also common on N. German farms investigated in 1979. Moreover, it has recently been found on farms in England, Switzerland and Canada. However, tests of housefly samples from many parts of the world in the 1970's indicated that kdr was rare in most other regions, and DDT-R was mainly due to dehydrochlorination by DDT-ase. In areas where kdr is common, high pyrethroid-R develops rapidly in fly populations exposed to intensive pyrethroid-pressure, as kdr is combined with other R-factors or replaced by super-kdr. In areas where kdr is rare or absent, e.g. in Japan and China, pyrethroid-R may take a long time to develop. Thus monitoring for kdr is very important before deciding whether and how to use pyrethroids for fly control.

**S17.1.** A MUTANT ALI-ESTERASE AND INSECTICIDE RESISTANCE IN THE SHEEP BLOWFLY,  
**5** LUCILIA CUPRINA

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The major mechanism of resistance to organophosphorus insecticides in L. cuprina has been identified as an esterase hydrolysing phosphate esters. Electrophoretic and genetic studies were undertaken on adult blowflies from laboratory strains and field samples. The results will be discussed within the context of the "mutant ali-esterase" theory of insecticide resistance, first proposed for the housefly. Additional data will be presented on other mechanisms which contribute to resistance in L. cuprina; these data demonstrate the similarity between the housefly and the blowfly in the development of insecticide resistance in the two species.



517.1.  
6

RESISTANCE OF THE HOUSEFLY TO ORGANOPHOSPHATE AND  
CARBAMATE INSECTICIDES IN TAIWAN

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Taiwan, ROC, has a population of 18.5 million in an area of 36,000Km<sup>2</sup>, one third of which is suitable for agricultural farming. Insecticides have been heavily applied during the past three decades. This report presents data on the insecticide resistance of the housefly, *Musca domestica* L., collected from all parts of Taiwan. The island was divided into eight districts from which flies were collected and reared in the lab. Only female adults of F1 and F2 were used for testing. Data obtained from tests of insecticide resistance for wild houseflies were compared with those for a susceptible strain of this species, and values for a resistance factor (R.F.) were computed. Nine organophosphate and two carbamate insecticides were used in these tests. Three of them (dichlorvos, pirimiphosmethyl, and propoxur) have been used in urban areas for many years. The others have been used mainly in agricultural farms.

The results show that the housefly throughout Taiwan has developed a high degree of resistance to all of the insecticides tested with very little exception. Propoxur, carbaryl, trichlorfon and malathion have lost practically all their effectiveness against field strains of the housefly. For all of the other insecticides except dimethoate the R.F. values were mostly from 10 to 55. The R.F. values for dimethoate ranged from 1.7 to 8.3 for the eight districts. Although most of the insecticides tested had not been used for urban insect control, houseflies collected from urban areas showed considerable resistance to each one. This phenomenon could be due to (1) the overlapping of agricultural and urban areas in Taiwan and (2) cross resistance.

517.1. STUDY OF THE LEVELS OF SUSCEPTIBILITY TO APHICIDES  
7 IN CEREAL AND BEEN APHIDS

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The authors monitored the susceptibility and analysed possible inducement of resistance to dimethoate, methylparathion and phosalone in three species of cereal aphids *Schizaphis graminum*, *Microsiphum avenae* and *Rhopalosiphon padi* in the Krasnodar Territory and in *Acythosiphon pisi* in the Voronezh Region, using diagnosis concentration. No change in the susceptibility of field populations to the used aphicides was revealed.

In a series of 2I generations of *M. avenae* and *Sch. graminum* II selections by phosalone in laboratory did not change the level of susceptibility. The phosalone selection of *A. padi* during 60 generations did not very the susceptibility to the selection agent.

## **S17.1.** SELECTION FOR AND MANAGEMENT OF INSECTICIDE RESISTANCE IN MOSQUITOES

**8**

C. F. CURTIS and J. D. LINES

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Evaluation of the prospects for proposed methods of management of resistance depends on knowledge of the source and strength the selection for and against resistance genes. We have reared resistant and susceptible strains of several mosquito species and measured mortalities after exposure to insecticide deposits which have been sprayed into huts or breeding places. Effects of resistance genes on rate of development in the absence of insecticides have been measured. Evidence has been reviewed on the question of whether agricultural insecticides are the main source of selection for resistance in mosquitoes.

## **S17.1.** THE ROLE OF THE APPLICATION PROCESS IN THE DEVELOPMENT OF INSECT RESISTANCE

**9**

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The delivery of pesticides to plant surfaces is a very inefficient process. The development of more active agents as well as environmental concerns make it imperative that we increase this efficiency. Current studies of grower applications show unacceptable levels of precision which can aggravate the resistance (R) problem. Dose targeting encompasses the definition of the biological target (crop and pest) and dictates the subsequent dose delivery protocol. Some recent R models show coverage is a major factor in the development of R. Correct coverage is dictated by the proper match of equipment, transport processes and physiochemical properties, pest, target, and population identification by the well-trained operator. Implementation of dose targeting protocols appears limited by lack of: flexibility in current equipment, basic information on biological targets, and information on placement rules. Resistance management can be enhanced by studies on formulation/application systems that place doses on targets in a manner consistent with saturation concepts. New R monitoring techniques offer unique opportunities to develop meaningful information on R with various dose transfer systems (CDA, ULV/OIL, electrostatics, etc.). This will require increased team research on basic mechanisms of delivery, impingement, and dose responses of pests to dose/drop density coverage parameters.

**S17.1.** SELECTION FOR MALATHION RESISTANCE IN THE GRAIN BEETLE ORYZAEPHILUS  
**10** SURINAMENSIS AND ITS IMPLICATIONS FOR PLANNING INSECTICIDE TREATMENTS.

JOHN MUGGLETON

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The effect of selection with malathion on strains of the grain beetle Oryzaephilus surinamensis resistant and susceptible to the insecticide has been studied over a number of generations. From these studies it has been possible to estimate the relative fitness of the malathion resistant phenotypes in the presence and absence of the insecticide. The fitness values obtained have been fitted to current models describing the evolution of resistance. The results show that the best compromise between slowing the spread of resistance and control of the pest would be achieved when doses of insecticide high enough to kill all susceptibles and all, or a large proportion, of the resistant heterozygotes are used in such a way that a proportion of the population escapes treatment.

**S17.1.** HOW TO USE PYRETHROIDS FOR FLY CONTROL WITHOUT GETTING SERIOUS  
**11** RESISTANCE PROBLEMS. EXPERIENCE FROM DANISH FARMS.

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<sup>2</sup>Retired

(R = resistance)

Aerosols and space sprays with pyrethrum + piperonylbutoxide (PY+PB) were used for fly control on Danish farms 1950-1970 without serious problems of R to PY-PB. In field trials 1971-73 moderate to high R developed rapidly on many farms with frequent, i.e. twice a week or more, aerosol treatments with PY-PB or other non-residual pyrethroids, or where automatic aerosols were installed. Recent trials show similar results. However, on farms with aerosol treatments at a week's interval or more low R to pyrethroids did not increase generally and the aerosol treatments continued to be effective. On the other hand once a fly population had developed pyrethroid-R this would in many cases remain high the following year(s) even if the frequency of the aerosol treatments was reduced.

Based on these results we recommended that the frequency and extent of using pyrethroid-aerosols or space sprays should be reduced to decrease the selection pressure by allowing more unexposed flies to reproduce. Moreover, the use of automatic aerosols was disparaged and we persuaded the authorities and companies not to register residual pyrethroid formulations for fly control on farms. The result is that the aerosols are still effective on most Danish farms in spite of the general high potential for development of pyrethroid-R. The lack of R-development is illustrated by recent surveys from a great number of farms.

**517.1.** SYNTHETIC PYRETHROID RESISTANCE IN HELIOTHIS ARMIGER (HUBNER) IN  
**12** AUSTRALIA

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Insecticide resistance in Heliothis armiger (Hübner) has been monitored Australia wide at Tamworth, N.S.W. since 1975 by the New South Wales Department of Agriculture. Considerable base line data has been established by topical application for a range of insecticides including the synthetic pyrethroids. The synthetic pyrethroids have been used in Australia since 1977, but there was no evidence of resistance until January 1983 when strains from Emerald, Queensland showed at least 50% of individuals were resistant. Resistance factors were estimated as 10x, 15x, 25x and 50x for permethrin, cypermethrin, deltamethrin and fenvalerate respectively. A resistance survey in 1983 has indicated a low overall frequency of resistant individuals in cotton and other cropping areas of Queensland and New South

**517.1.** FIELD EVALUATION OF AN INSECTICIDE MANAGEMENT STRATEGY FOR  
**13** PYRETHROID RESISTANT HELIOTHIS ARMIGER (HÜBNER) IN AUSTRALIA.

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Resistance to synthetic pyrethroids was confirmed in Heliothis armiger (Hübner) in Australia in early 1983. Very soon after, an insecticide management strategy was developed to try to prolong the useful life of these chemicals for control of Heliothis armiger in field crops and vegetables. Basically, the strategy relies on restricting the use of the pyrethroids to a 42 day period in the middle of the summer cropping season. Thus, pyrethroids are restricted to only one of the four or five generations of H. armiger, which can occur in a season. Control outside this period, will rely on the rotation of unrelated chemical groups (eg. organophosphates, organochlorines, carbamates and chlordimeform).

The full strategy will be outlined and its impact on resistance levels will be evaluated for the coming 1983/84 summer cropping season.

**S17.1.** METABOLISM OF INSECTICIDES AND NEGATIVELY CORRELATED CROSS-RESISTANCE  
**14** IN THE BROWN PLANTHOPPER

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Insecticide resistance is one of the evolutionary phenomena, therefore it is difficult to avoid insecticide resistance. However, it is possible to control the development of insecticide resistance by an appropriate use of insecticides (e.g. the combination of insecticides with negatively correlated cross-resistance).

In the brown planthopper (BPH, Nilaparvata lugens Stål), a negatively correlated cross-resistance was observed between fenvalerate and malathion. To clarify the mechanism of this phenomenon, metabolism of fenvalerate and malathion by the BPH was studied. There was a good correlation between -naphthyl acetate hydrolyzing activity and resistance level to malathion, but not to fenvalerate. A good correlation was also observed between in vitro malathion degradation activity and resistance level to malathion. However, no correlation was observed in fenvalerate resistance. The correlation between in vivo metabolism and resistance level will be also discussed.

**S17.1.** CHALLENGES AND PROSPECTS TO PESTICIDES RESISTANCE - BIOCHEMICAL  
**15** MONITORING FOR RESISTANCE IN RICE LEAFHOPPER AND PLANTHOPPERS

TETSUO SAITO AND TADASHI MIYATA, Laboratory of Applied Entomology and Nematology, Faculty of Agriculture, Nagoya University, Nagoya, 464 Japan

The monitoring for resistance is one of the important point of challenge to pesticide resistance and bioassay method have been used. However, they required large numbers of insects and long period of time to obtain results.

There was a good correlation between high aliesterase activity and organophosphorus insecticide resistance in the green rice leafhoppers, smaller brown planthoppers and brown planthoppers. Enzymes of the leafhoppers and planthoppers were separated by agar-gel electrophoresis, and aliesterase patterns were found to be associated with the degradation of malathion. Biochemical monitoring for organophosphorus resistance in rice leafhopper and planthoppers was developed by using aliesterase determination.

No correlation was observed between aliesterase activity and carbamate resistance. The substrate specificity to ATCh was different between susceptible and carbamate resistant strains of insects. Biochemical method to monitor for carbamate insecticide resistant was developed by using high concentration of ATCh.

These biochemical monitoring methods are quite simple for assaying individual insects of the population in rice leafhopper and planthoppers.

**P17.-**  
**1** INSECTICIDES IN AERIAL FOREST SPRAYING: A COMPARISON  
OF EFFICIENCY AND SIDE EFFECTS ON THE BENTHIC ORGANISMS.

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A comparison of efficiency of chemical insecticides (Actellic, Ambush) used against the larch bud moth (*Zeiraphera diniana*) in mountain spruce forests in Krkonoše Mts. (Czechoslovakia) with biological insecticide Thuricide HP (Sandoz Inc.) is given. Both groups of insecticides were investigated with special reference to side effects on the benthic organisms in streams in treated areas. The maximal mortality of pest was found 85 % in Actellic and Ambush and 90 % in Thuricide. High degree of mortality of non-target arthropods was associated with an application of the mixture of Actellic and Ambush. But no side effects on aquatic organisms were ascertained in the Thuricide. These results were proof by an bioessay on model organisms under laboratory conditions.

**P17.-**  
**2** AN APPLICATION OF THE THEORY OF PESTICIDE RESISTANCE MANAGEMENT TO  
SPIDER MITE RESISTANCE IN CALIFORNIA COTTON

TIMOTHY DENNEHY and JEFFREY GRANETT, Dept. of Entomology, University of California, Davis, California 95616 USA

Selective miticides are key components of integrated pest management (IPM) in California cotton. A project to develop strategies to prolong the useful life of cotton miticides was initiated in 1981. Resistance to the miticide, dicofol, was described and a discriminating-concentration bioassay was designed for monitoring dicofol-resistance in cotton. A sampling/bioassaying procedure was developed, and field-tested. Based on observed within-field variability in susceptibility estimates, a critical frequency (the frequency at which use of dicofol no longer yields satisfactory control) was established for dicofol resistance. Dicofol susceptibility was monitored on a regional basis in cotton throughout the San Joaquin Valley in both 1982 and 1983. During both seasons, over 85% of the locations monitored had early-season frequencies of resistant mites that were below the critical frequency and at many locations no resistant spider mites were detected. A rapid bioassay technique suitable for use in the field is under development. Studies of cross and multiple resistance are underway. Susceptibility data and information from life table studies of R and S spider mites will allow development of chemical usage recommendations tailored for specific areas which maximize the useful life of selective miticides.

P17.-  
3

INSECTICIDE RESISTANCE IN FIELD POPULATIONS  
OF HOUSEFLIES IN YUGOSLAVIA

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University of Belgrade, INEP, Department of pesticides, Zemun

In order to study the development of insecticide resistance in houseflies (Musca domestica L.) the authors tested their susceptibility to dieldrin, lindane, malathion, dichlorvos, bendiocarb and deltamethrin during two years. Houseflies collected in regions with different histories of their control and a susceptible laboratory strain were used in the experiments.

Susceptibility was tested by topical application and mortality from insecticide exposure was analyzed by probit analysis.

Most of the tested field populations were resistant to malathion. A small number of populations was resistant to bendiocarb but no resistance to deltamethrin was found at all.

The results obtained are discussed in relation to the history of chemical control of flies.

P17.-  
4

LINKAGE BETWEEN MALATHION AND DIELDRIN RESISTANCE IN  
ANOPHELES ARABIENSIS

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Crosses were performed to detect genetic linkage between the genes conferring resistance to dieldrin and malathion in a Sudanese strain of Anopheles arabiensis.

In two sets of backcrosses, the observed rates of recombination were 12.6 and 7.5 %. There is evidence that these are over-estimates.

In a Y - translocation strain, there was less than 2.8 % recombination between the loci.

The two resistance mechanisms are biochemically distinguishable.

The significance and possible consequences of the linkage between the genes for malathion, dieldrin and DDT are discussed.

**P17.-**  
**5** THE INSECTICIDE RESISTANCE ACTION COMMITTEE OF GIFAP:  
OBJECTIVES AND OPERATION

G. VOSS  
Chairman IRAC  
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The "Insecticide Resistance Action Committee" (IRAC) provides expert advice to GIFAP (International Group of National Associations of Agrochemical Manufacturers) on all technical and scientific matters related to insecticide resistance. IRAC will establish and foster relationships with industrial and non-industrial researchers (academia, governments, international organizations) to define and recommend suitable strategies to prolong the life of valuable insecticides/acaricides in the face of resistance.

IRAC has established several working groups on a problem type basis. They will identify existing and potential resistance problems, set research priorities, prepare position papers, and communicate their findings to those involved in research, registration, distribution and use of insecticides/acaricides.

Persons with experience in the field of insecticide resistance are invited to cooperate with IRAC's working groups. The 17. International Congress of Entomology offers a chance for first personal contacts.

**P17.-**  
**6** MATHEMATICAL EVALUATION OF OPTIONS FOR MANAGING PESTICIDE  
RESISTANCE

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Australia

The central problem of pesticide resistance management is to extend the useful life of pesticides, so that development of new chemical agents will outpace the development of resistance by pests. This must be achieved while maintaining adequate control.

Simple mathematical models, based on our knowledge of the population genetics of resistance, can be used to investigate the usefulness of various strategies of pesticide use in delaying resistance. I consider the following options: (i) timing of applications relative to seasonal population growth, (ii) restricting application to particular areas to provide "refuges", (iii) using dosages lethal to resistant heterozygotes, (iv) alternating pesticides in space or time.





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R 18.2. Microbial Control .....  
R 18.3. Insect Viruses .....  
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**R 18.1.**

**1**

A NEW ISOLATE OF BACILLUS THURINGIENSIS  
EFFECTIVE AGAINST COLEOPTERA

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In 1982 a new strain of Bacillus thuringiensis has been isolated in Darmstadt from Tenebrio molitor (Coleoptera: Tenebrionidae). According to its biochemical features our crystalliferous strain belongs to a new subspecies: B. thuringiensis var. tenebrionis. After peroral application of crystals and spores to larvae of several Coleoptera a dosage-dependent pathological reaction was induced: frass stop followed by a remarkable mortality caused by primary lesions of the larval midgut and a subsequent septicemia. - Lepidopterous larvae and mosquito larvae, however, are not sensitive against crystals and spores of that new isolate.

**R 18.1.**

**2**

BIOCHEMICAL STUDIES ON THE COLEOPTERA TOXIC BACILLUS  
THURINGIENSIS VAR. TENEBRIONIS

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We are investigating the biochemical properties of the recently described strain Bacillus thuringiensis var. tenebrionis (Krieg et al. 1983, Z. ang. Ent. 2:500). Purified crystals show two major protein fractions in SDS-PAGE. The mol. wt. is 70kDa and 65kDa respectively. Crystal proteins of B.t.t. show no cross reaction with antibodies against crystal preparations from B.t. var. kurstaki and B.t. var. israelensis. The plasmid pattern contains at least three plasmids with mol. wts. of more than 65MDa. The non-toxic cry<sup>-</sup> phenotype seems to be associated with the absence of one of those large plasmids. We are currently trying to verify this observation.

**R18.1.** OCCURRENCE OF MOTILE STREPTOCOCCI AND ITS PATHOGENICITY  
**3** IN SILKWORM LARVAE, BOMBYX MORI

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A high incidence of flagellated streptococci was obtained from the intestine of the silkworm larvae, Bombyx mori. These organisms markedly predominated during later developmental stages of the larva, and were identified as motile Streptococcus faecalis on morphological, biochemical and serological tests. This S. faecalis ( $F^+$ ) multiplied exponentially in compromised larvae and rapid fatal course was observed in the larvae. While, in the determination of virulence factor of  $F^+$  strain, flagella less mutant strain ( $F^-$ ) was mutanized with ethyl methanesulfonate. Both  $F^+$  and  $F^-$  strains were biochemically and morphologically identical. However, the  $F^-$  strain showed a sever loss of virulence in aseptically reared larvae. Therefore, it seemed that the motility of S. faecalis has an important step in the infectious process in the silkworm larvae.

**R18.1.** STUDY OF STAPHYLOCOCCUS, RICKETTSIA-LIKE AND MYCOPLASMA-LIKE  
**4** ORGANISMS IN TRICHOGRAMMA SPP. AND DISEASES CAUSED BY THEM

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Staphylococcus sp., rickettsia-like organism (RLO) and mycoplasma-like organism (MLO) were found to infect Trichogramma confusum and T. dendrolimi.

The Staphylococcus sp. infected the eggs, larvae, pupae and adults and was found in the cells of some tissues. The infected adults showed fragile and darker in body-color and died eventually.

The RLO could be detected from the larvae, pupae, and adults and infected mainly the cytoplasm of fat-body and the epithelial cells of integument. The infected adults showed various signs of abnormalities, such as vestigial wings, shorter life span, reduction of emergence rate, less fecundity, inertness, etc. and even resulted in death.

The MLO infected the larvae and adults and occurred in the cytoplasm of cells of tissues in the head.

Results from experiments showed that the diseases caused by Staphylococcus and RLO could be controlled to certain degree with penicillin, streptomycin, chloramphenicol and tetracycline.

**R18.2.** STUDIES ON *BACILLUS THURINGIENSIS* VAR. *ISRAELENIS* AND *B.SPHAERICUS*  
**1** (1593) FOR THE CONTROL OF SOME MOSQUITO LARVAE

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Department of Biology, Chulalongkorn University

The microbial insecticide, *Bacillus thuringiensis* var. *israelensis* and *B.sphaericus* can be used to control larval mosquito population in Thailand. The effects of the bacteria were conducted on mosquito larvae, *Aedes aegypti*, *Culex quinquefasciatus*, *Anopheles balabacensis* and *An.minimus*.

The  $LC_{50}$  values (24 hrs.) for *B.thuringiensis* var. *israelensis* against *Ae.aegypti* were 0.12 and 0.23 ppm for 3rd and 4th instar larvae, respectively. The  $LC_{50}$  values (24 hrs.) of *B.thuringiensis* var. *israelensis* in opposition to *Cx.quinquefasciatus* were 0.15 and 0.22 ppm; *An.balabacensis* were 0.34 and 0.64 ppm; and *An.minimus* were 16.5 and 18 ppm. for 3rd and 4th instar larvae, respectively. The  $LC_{50}$  values (24 hrs) of *B.sphaericus* (1593) against *Cx.quinquefasciatus* were 0.068 and 0.17 ppm for 3rd and 4th instar larvae respectively.

The  $LC_{50}$  values for *B.thuringiensis* var. *israelensis* increased with higher instars and a shorter exposure time. A concentration of equal or more than the  $LC_{50}$  controlled 90 to 100% of the larval mosquito population for a period of one week. The stock of bacterial suspension decreased its activity after being left in room temperature condition for 48 hrs., and lost activity after one week.

**R18.2.** CONTROL OF SPODOPTERA LITTORALIS THROUGH MOTH AND EGG  
**2** TREATMENT WITH BACILLUS THURINGIENSIS

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The effectiveness of *Bacillus thuringiensis* var. *galleriae* HD-129 against the moths and egg masses of the cotton leafworm *Spodoptera littoralis* has been demonstrated in laboratory experiments. The longevity and egg production were significantly affected when the moths were fed on a sucrose diet containing 17200 IU of the tested formulation/mg or higher rates. At lower concentration (4400-8700 IU/mg), the females gave normal egg production but the longevity was adversely affected. Investigations show that a formulation with spores alone affected the egg production and hatching while a formulation with active crystals alone had no effect on egg production. Sprays of *B.thuringiensis* combined with sucrose on flowering cotton plants seem to affect the biology of the moths released on it. Egg masses sprayed with *B.thuringiensis* hatched normally, but the survival of the hatched larvae was reduced when treatment was made shortly before egg hatching. Based on the results obtained, *B.thuringiensis* showed a promising effect in the control of the moth *S.littoralis* and it may act as an ovicide larvicide agent.

## R18.2. THE EFFECT OF BACTOSPEINE AND DIMILIN IN CONTROLLING OLIVE MOTH

### 3 (PRAYS OLEAE)

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A trial was conducted for studying the insecticidal effect of a Bacillus thuringiensis preparation (Bactospeine) and a chitin inhibitor (diflubenzuron-Dimilin) for the control of the anthophagous generation larvae of the Olive Moth (Prays oleae) in olive trees.

A spray was conducted on May 19, 1983, with Bactospeine covering an area of 200 olive trees. In another area with the same number of trees, Dimilin was used. Trees around the sprayed areas were used as checks.

The mortality effect on larvae, based on surviving adults of Prays, after spraying with Bactospeine and Dimilin was : 89,4% and 83,4% respectively, compared to the check.

The infestation on fruits, based on the number of deposited eggs (on June 2, 1983) was: 24,3% in the Bactospeine area, 55,7% in the check, 42,8% in the Dimilin area and 48,3% in the check.

At the pre-harvest period (October) a fruit drop caused by Prays was estimated: in the Bactospeine area, it was 26,8% of the total dropped fruit, while in the check it was 61,5%. Data for the Dimilin area were : 40,5% and 49,4% respectively.

## R18.2. PROSPECTS AND ECONOMICS OF MICROBIAL CONTROL OF THE TOMATO

### 4 FRUITWORM IN SOUTH-WESTERN NIGERIA

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The literature records relatively few studies on the economics of microbial control of the tomato fruitworm, Heliothis armigera (Hub) (Lepidoptera, Noctuidae); in Nigeria, such studies have only been embarked upon of recent. The authors report on field and laboratory experiments to evaluate commercial formulations of Bacillus thuringiensis Berliner (B.t.), and Baculovirus heliothis plus certain adjuvants as microbial control agents of H. armigera and Spodoptera littoralis (Boisd.), major pests of the tomato in Nigeria. The economics of application of these microbial control agents was also computed. B.t. was found to be efficient in controlling the pests, and to yield favourable returns on investment. The results show bright prospects for this method of pest control on tomato.

### **R18.3.** IN VITRO REPLICATION OF THE CHORISTONEURA MURINANA **1** NUCLEAR POLYHEDROSIS VIRUS

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The nuclear polyhedrosis virus of the European fir budworm, Choristoneura murinana, (Cm NPV) is a very interesting baculovirus. It is pathogenic for a relatively large number of insect species, amongst which are such important pest species as Choristoneura fumiferana (spruce budworm), Cydia pomonella (codling moth), Cydia funebrana (plum fruit moth), and Rhyacionia buoliana (European pine shoot moth). Another striking phenomenon is the formation of proteinaceous spindle shaped bodies during its replication.

We succeeded in establishing an in vitro replication system for Cm NPV. Both, polyhedra and spindles, are produced during the in vitro replication cycle in a Cydia pomonella cell line (IZD-Cp-0508). Our biochemical data indicate that the virus produced in vitro is identical to the Cm NPV originally used to inoculate the IZD-Cp-0508 cells. The in vitro polyhedra are as infectious in a bioassay with Cydia pomonella larvae as are the in vivo ones.

This in vitro system will enable us to study the replication cycle of Cm NPV, and especially the formation of the proteinaceous spindles, in detail.

### **R18.3.** ANALYSIS OF THE NATURAL SPREAD OF INSECT VIRUS DISEASES IN RELATION TO **2** PEST CONTROL

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The practical use of viruses to control pest insects relies on two main methods; firstly, dispersion in sprays and secondly, dispersion through natural agencies. The latter, which may be regarded as classical biological control, is now amenable to analysis and is the subject of this paper.

The pattern of primary dispersal from initially small epicentres of disease follows an indented curve of rapidly diminishing disease incidence with distance. Logarithmic transformation of the units of both disease quantity and distance reveals a linear relationship. There is evidence the slope of this line, known as the gradient of dispersal, is constant for particular host-virus associations. Epicentral flattening of the primary dispersal curve precedes the development of a wave-like pattern, the secondary dispersal phase. Following this, the wave form is lost, the pattern of dispersal becomes less coherent and is identified as the interference phase because of the interacting and confusing role of expanding adjacent secondary epicentres.

This evolution is illustrated by examples of baculovirus disease spread in populations of Lepidoptera, Hymenoptera and Coleoptera. Its place as a control strategy is discussed.

**18.3.**  
**3** NUCLEAR POLYHEDROSIS DISEASE OF Spodoptera littoralis  
TRANSMITTED VIA EGG AND PUPAL EXPOSURE TO VIRUS .

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Surface contamination of Spodoptera littoralis egg masses was made with different concentrations of polyhedra suspension. The results indicate a considerable rate of disease occurrence among hatched larvae. The test includes eggs exposed as newly deposited and others as about to hatch. The study draws attention to the eggs as a spray target in the use of the virus in the pest management.

The exposure of pupae to polyhedra was made either directly or indirectly, as the latter simulates the nature of the pest which normally pupate inside the soil. Emerged adults were paired in combination with untreated ones. The rate of disease transmitted to offspring larvae was generally low. However, the exposed females were particularly responsible of a relatively higher rate of disease transmission.

The surface sterilization of polyhedra-treated eggs or pupae, by exposure to formaline vapour, prevented the transmission of the disease.

The economic importance of the disease transmission via eggs and pupae is discussed in view of the behaviour of the pest on cotton.

**R18.3.**  
**4** ANTI-VIRAL PROTEINS IN MID-GUT OF THE SILKWORM, BOMBYX  
MORI L.

ROGER F. HOU AND C. S. CHIU

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Mid-gut proteins from the silkworm fed on an artificial diet containing dried power of the spiral alga, Spirulina platensis, have a very low fluorescent intensity, indicating that chlorophyll a in this alga is not synthesized to be the red fluorescent protein (RFP) which has been considered to be an effective anti-viral protein in silkworm mid-gut. Many bands of the mid-gut protein from the mulberry-fed silkworms emitted red fluorescence under UV light when separated using DISC polyacrylamide gel electrophoresis. It is thus concluded that the RFP as a whole is more than one mid-gut protein. Enzymatic analyses have revealed that phospholipase C but not protease is virtually one of the anti-viral factors in the RFP of the silkworm mid-gut.



**R18.3.**  
**5**

THE VIRUS PATHOLOGY OF THE GRAPE BERRY MOTH,  
LOBESIA BOTRANA

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The grape berry moth (Lobesia botrana Den.& Schiff. Lepidoptera: Tortricidae) is one of the important pests of vineyards of the USSR. The role of the biotic factors, especially the pathogens in the regulation of its populations has been established by 5-year observations in vineyards of the Georgian SSR, where L. botrana has three generations a year. The populations were completely free from virus invasion.

Laboratory experiments established that larvae of L. botrana were susceptible to a GV, Baculovirus (Granulovirus) orana Oho. and NPV, Baculovirus (Polyhedrovirus) ocellana Chkhub. Preliminary experiments were undertaken and showed that GV can be used to control outbreaks of L. botrana in the natural conditions. The investigations are being continued for study of the double infection of L. botrana with a GV and NPV.

**R18.3. INSECTICIDIAL ACTIVITY OF BACULOVIRUS PREPARATIONS**  
**6**

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Methods are described for activity assessment of Baculoviruses and their formulations, which are designed to control Gypsy Moth, Codling Moth, cabbage armyworm and some other agricultural and forestry pests.

**R18.3.** SUSCEPTIBILITY OF THE COCONUT PALM RHINOCEROS BEETLES  
**7** ORYCTES MONOCEROS AND O. RHINOCEROS TO ORYCTES BACULOVIRUS

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Rhinoceros Beetles are important pests of coconut palms. O. rhinoceros, which has been artificially introduced from S.E. Asia into the South Pacific Islands could be successfully controlled by a Baculovirus (BV) disease from Malaysia. The BV disease does not seem to exist in O. monoceros, which is distributed along the coast of tropical Africa. In laboratory tests, O. monoceros from Ivory Coast could also be infected with the BV, but were less affected compared with the original host. In the Seychelles Islands however, BV from Samoa was successfully released and is persisting in the local O. monoceros population since 1972.

The suitability of the BV for Biological Control of O. Monoceros was studied in Tanzania. The effect of the disease on adults is described and the chances of a successful field-release are discussed. By comparing ID50 values it was shown, that local O. monoceros were far less susceptible to a virus isolate from the Seychelles than specimens from the Seychelles. O. monoceros adults were also less susceptible to another isolate, coming from Samoa, compared with the original host O. rhinoceros from the Philippines, but the difference was less than with the Seychelles isolate.

**R18.4.** IN VITRO PHAGOCYTOSES OF SEVERAL INSECT CELL LINES AND  
**1** THE HEMOCYTES OF MAMESTRA BRASSICAE

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In order to study phagocytoses by insect hemocytes in vitro, an attempt was made to obtain a cell line of hemocytes which would be a suitable experimental material. Consequently, continuous cell lines of hemocytes were obtained from the cabbage armyworm, Mamestra brassicae.

Phagocytic reactions of several insect cell lines including the new hemocyte lines and of the hemocytes in primary cultures were studied. All of the cell lines and the hemocytes showed phagocytoses. However, the rate and the speed of phagocytic reactions were different depending on the cell line species or the sort of inocula.

Effects of phenoloxdase on the phagocytosis by insect cells were examined also.

**R18.4.** DEFENSIVE REACTIONS OF GALLERIA MELLONELLA L. UNDER THE  
**2** INFLUENCE OF THE PARASITE NEMATODES AND THEIR BACTERIA

SAADIA GHALLY and HENRYK SANDNER

AIN SHAMS UNIVERSITY, CAIRO, WARSAW AGRICULTURAL UNIVERSITY

The authors compared defensive reactions /change in number of haemocytes/ of *Galleria mellonella* caterpillars to infestation by *Neoaplectana carpocapsae* Weiser and *Xenorhabdus nematophilus* /Poinar and Thomas/ and by *Heterorhabditis bacteriophora* Poinar and bacteria connected with them. In all cases a strong reaction was observed but higher by *N. carpocapsae* and *X. nematophilus* than by *H. bacteriophora* and their bacteria. Haemocytes increased their number two times: after 12 and 24 hours by nematodes and after 12 and 36 or 68 hours by their bacteria.

**R18.4.** THE STUDY OF RESISTANCE OF INSECTS TO *Bacillus*  
**3** *thuringiensis*

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The conditions for resistance development of insects *Pieris brassicae* L. and *Galleria mellonella* L. to *Bac. thuringiensis* have been determined. The decrease in death intensity and increase in survival periods of larvae have been ascertained. Qualitative and quantitative changes in hemocytes of insect hemolymph under the influence of *Bac. thuringiensis* point to the developmental process of insect resistance to bacteria. Positive reactions of precipitation of hemolymph proteins and *G. mellonella* larvae extracts with water-soluble proteins of *Bac. thuringiensis* have not been revealed. *Bac. thuringiensis* provoke the blocking of arylesterase isoenzyme synthesis in *G. mellonella* larvae that has been found to have relation with resistance development of insects to bacteria.

**R18.5.** THE ROUTE OF FUNGAL DEVELOPMENT OF VERTICILLIUM LECANII IN APHIDS  
**1**

H WILLIAMS

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Spore settlement on aphid cuticle is followed by either penetration and a subsequent invasive development within the aphid or saprophytic surface growth. The invasive development which gives rise to host death has been investigated histologically, and six stages have been identified:

- 1) spore settlement
- 2) spore germination
- 3) surface mycelial spread
- 4) spore penetration
- 5) invasive development
- 6) secondary spore production

**R18.5.** ENHANCED CULTURE OF BEAUVERIA BASSIANA BY INCORPORATION  
**2** OF INSECT MATERIAL INTO THE GROWTH MEDIUM

REFAT EL-SUFTY

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The entomogenous fungus, Beauveria bassiana (Bals.) Vuill., was cultured through six successive transfers on two media: peptone malt agar or the same medium in which peptone was substituted with powdered, dried larvae of Galleria mellonella L. This substitution maintained germination of conidia, mycelial growth, production of conidia, and virulence of the fungus, during successive transfers. All these characters were gradually reduced during successive transfers on peptone malt agar.

**R18.5.** SELECTION OF COMMERCIAL STRAINS OF THE FUNGUS  
**3** BEAUVERIA BASSIANA /BALS/ VUILL

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of Microbiological Agents for Plant Protection

The morphological, physiological and biochemical properties of the fungus were studied. Indices characterizing highly active strains were determined, and the conditions for storing the strains were studied. A scheme for selecting active strains for submerged cultivation, based on comprehensive evaluation, is proposed.

**S18.1.**  
**1**

INTRODUCTION

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The most important measure of the competence of an immunologic system is its ability to distinguish between the "self" and "non-self" tissue. In mammals, this competence is due to the presence of immunoglobulins or serum proteins that act as recognition factors. Although the hemocytic and humoral immunity is not well known in all major arthropod groups, we do know that arthropods possess hemolymph recognition factors, called agglutinins or lectins. The nature, synthesis, distribution, and possible roles of agglutinins in various groups of arthropods will be discussed. It is now known that the ubiquitous granulocytes and the plasmatocytes play important roles in the synthesis of agglutinins, activation of the phenoloxidase system, and recognition and encapsulation of the foreign antigen. Evidence will be presented to show that the phenoloxidase system indeed plays an important role in the recognition process in Crustacea and Insecta. The biochemical modus operandi of this process as well as the details of the hemocytic and humoral encapsulation mechanisms will be presented. It will be demonstrated that hemocytes that turn malignant lose their capacity to recognize "self" tissue.

**S18.1.** LECTINS FROM CHELICERATES: DISTRIBUTION, SPECIFICITY AND POSSIBLE  
**2** BIOLOGICAL ROLE.

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Among the possible candidates responsible for non-self recognition at the molecular level in arthropods, the carbohydrate-binding molecules (lectins) are the best characterized in their specificity, physicochemical properties and molecular structure. Arthropod lectins are multimeric, high molecular weight protein (glycoprotein) molecules with a certain degree of heterogeneity in their specificity and structure. Their exact role in recognition functions has not been fully explored and their function remains unclear.

Research on the distribution and specificity of serum lectins in Merostomata (horseshoe crabs) and Arachnida (scorpions, whip scorpions and spiders) showed that the species studied so far exhibit lectins which bind sialic acids.

In addition to this common feature of specificity, lectins from chelicerates represent heterogeneous populations which can bind a wide variety of carbohydrates, many of them present in bacteria, such as D-galactose, 2-keto-3-deoxy-octonate, glucuronic acid, N-acetylmuramic acid, and colominic acid. Multiplicity in specificity suggests that serum lectins might contribute as a carbohydrate-based recognition system for the non-self. The requirement for avoiding self-recognition would be that carbohydrate structures potentially recognized by the system would be absent, masked or out of reach of this humoral factor or cell associated recognition factors.

**S18.1.** SYNTHESIS OF LECTINS BY SQUILLA MANTIS L. HEMOCYTES AND THE  
**3** POSSIBLE ROLE OF CELL GLYCOSYLATION IN THE RECOGNITION OF  
"SELF" AND "NON-SELF".

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In this work two lectins of the stomatopod Mantis Shrimp (Squilla mantis L.) are investigated by means of 6 monoclonal antibodies. These lectins are highly specific for human erythrocyte determinants of group O and A. The physico-chemical characteristics of these anti-H and anti-A lectins are similar, although they show physiological differences. We would like to speculate the possible role of species-specific terminal substitutions of oligosaccharides to discrimination between self and non self, as the peculiar results of pretreatment with some sugars suggest. We demonstrate, by means of immunoprecipitation with monoclonal antibodies, that anti-H and anti-A lectins are synthesized by a class of blood hemocytes, granulocytes. Moreover these lectins are present on granulocyte membrane, and the specific immuno-cyto-adherence let us to suppose that lectins could be membrane receptors and could play an important role in mechanisms of cellular defense.

**S18.1.** ROLE OF AGGLUTININS AND COMPONENTS OF THE PHENOLOXIDASE SYSTEM  
 4 IN THE RECOGNITION OF FOREIGNNESS BY INSECT HEMOCYTES

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Agglutinins are widely distributed within the Insecta, although as yet we have no evidence for any participation of these molecules in the defence mechanisms. For example, the haemagglutinins of Clitumnus extradentatus and Periplaneta americana although present in relatively high concentrations in the haemolymph have no apparent opsonic activity.

Our previous work described the role of one cell type, the granular cell/cystocyte in the induction of both nodule formation and encapsulation. We have now found that following microbial and macrobial challenge that these cells discharge their contents and this leads to the activation of the phenoloxidase system with the resultant formation of melanin and sticky proteins. These coat the foreign particles and enhance their uptake by the phagocytic plasmatocytes. This enhancement of phagocytosis has been demonstrated with in vitro studies where stimulation of the phenoloxidase system is brought about by the addition of either endotoxin or laminarin, a  $\beta$  1-3 glucan. How these factors bring about granular cell/cystocyte discharge will be discussed.

**S18.1.** HEMATOPOIETIC MALIGNANCIES OF GENETIC ORIGIN IN DROSOPHILA MELANOGASTER  
 5

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Four independent gene loci have been identified **which** in the mutated state cause malignant transformation of the larval plasmatocytes.

Mutant designation	Locus on Chromosom
lethal (1) malignant blood neoplasm	1 - 34.5
lethal (2) malignant blood neoplasm	II
lethal (3) malignant blood neoplasm -1	III
lethal (3) malignant blood neoplasm -2	III

In all four mutants the lymphglands are enormously enlarged and the blood cell count in the hemolymph is many folds increased. The malignant blood cells seem not to recognize "self tissue" and invade in situ as well as after transplantation in vivo into the wild type healthy tissues and, thus, cause the host's destruction. Histochemical-fine structur studies indicate that the tumor cells have much increased amounts of lysosomes and a number of fine structural abnormalities.

Shrestha,R. and E.Gateff (1982) Develop.,Growth and Differ. 24, 65-82

Shrestha,R. and E.Gateff (1982) Develop.,Growth and Differ. 24, 83-98

**518.1.** THE PROPHELOXIDASE ACTIVATING SYSTEM AND MELANIZATION AS A  
**6** RECOGNITION MECHANISM IN ARTHROPODS

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The ability to discriminate between self and non-self is a phenomenon universal throughout the animal kingdom. In mammals this is achieved primarily by specific antibodies and/or complement, but in invertebrates, which lack immunoglobulins, the biochemical and molecular bases for recognition of foreignness are still largely unknown. The prophenoloxidase activating system has recently been proposed to constitute a recognition system in arthropods, since it is specifically activated by  $\beta$ 1,3-glucans (carbohydrates from fungi) or cell walls of bacteria as well as lipopolysaccharides (LPS) and seems to be involved in regulating haemocyte behaviour in arthropods. In crustaceans the prophenoloxidase activating system contains opsoninlike factors can lyse crayfish haemocytes and produces fungitoxic compounds. Activation by  $\beta$ 1,3-glucans or LPS of prophenoloxidase present in the haemocytes of crayfish occurs via proteolytic action on the proenzyme, since serine protease inhibitors will completely prevent prophenoloxidase activation. Within the haemocyte lysate serine protease is present in an inactive form, which can be enhanced in activity by addition of  $\beta$ 1,3-glucans or LPS. In view of the multitude of biological functions the multi-step properties of prophenoloxidase activating system and activation by elicitors such as LPS or  $\beta$ 1,3-glucans, it is obvious that this system in Crustaceans and possibly in other arthropods serves as an important recognition and defence system.

**518.1.** IMMUNE RECOGNITION IN INSECTS, WITH SPECIAL REFERENCE TO  
**7** HAEMOCYTES

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Allogeneic tissues and, in some species-combinations, xenogeneic tissues are not recognised as 'foreign' by haemocytes; moreover abiotic surfaces of different charge and wettability may be recognised to different extents both within and between species. The mechanism by which immunological recognition of 'foreign-ness' occurs is thus capable of various degrees of discrimination, and this has a strong influence on the survival of parasites within their insect hosts.



**S18.1.** MACROPHAGE FUNCTIONS IN INSECTS: RESPONSES OF GALLERIA MELLONELLA  
**8** HEMOCYTES TO BACTERIAL INFECTION

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Injection of living Bacillus cereus, and other pathogenic and nonpathogenic bacteria, into the hemocoel produced a rapid reduction in the numbers of circulating hemocytes. This effect was produced by the virtual elimination of plasmatocytes from the hemolymph; the granulocyte count remained unchanged. Plasmatocyte depletion was dose dependent with regard to the numbers of bacteria injected. The response was mediated by a humoral factor released into the hemolymph, probably of hemocytic origin. Plasmatocyte depletion was produced in normal larvae following the injection of cell-free hemolymph from larvae previously challenged with bacteria. The factor was heat labile, its action temperature dependent, and could function in the absence of other humoral components. The release of this factor may be an early biochemical signal in the complex cellular response of G. mellonella to bacterial infection.

**S18.1.** SURFACE CHANGES ON HEMOCYTES DURING ENCAPSULATION  
**9**

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In melanotic tumor mutant (tu) larvae of Drosophila melanogaster aberrant tissues are encapsulated by blood cells, the lamellocytes. These cellular capsules later melanize and seal the abnormal tissues within impervious hardened walls. The same defense reaction is elicited against foreign tissues placed in the larval hemocoel.

Two subpopulations of lamellocytes are distinguished by wheat germ agglutinin conjugated to fluorescein isothiocyanate (FITC-WGA). One shows a fluorescent speckled surface (spk<sup>+</sup>) and the other lacks this characteristic (spk<sup>-</sup>). In tu larvae and larval hosts with heterospecific tissue implants, most of the lamellocytes are spk<sup>+</sup> whereas most of the lamellocytes in non-tumorous larvae are spk<sup>-</sup>. This suggests that the spk<sup>+</sup> lamellocytes differentiate under capsule-forming conditions.

To determine whether the capsule-competent state of the lamellocytes results from rearrangement (clustering) of molecules that were previously dispersed over the cell surfaces or from synthesis of new surface molecules, lamellocytes from tu larvae were treated with ferritin-labeled WGA and examined by transmission electron microscopy. Some lamellocytes had ferritin particles on their surfaces while others did not (presumably spk<sup>-</sup> cells). We interpret these observations to indicate that capsule-competent lamellocytes result from molecular differentiation of the cell surfaces.

PETER GÖTZ

Free University of Berlin (West), Institute of General Zoology

Encapsulation mechanisms in insects are either cellular or humoral in nature. During cellular encapsulation or nodule formation accumulations of blood cells around pathogens, parasites or foreign bodies result in the formation of solid envelopes. The following problems have to be discussed in detail:

- what makes blood cells react to these objects?
- which are the cell surface structures (molecules) reacting?
- are there soluble molecules involved?
- is there a sequence of cellular reactions with "alarm cells" (granular cells ?) reacting first and "encapsulating cells" (plasmatocytes ?) following?
- are these reactions identical independent of the nature of the objects encapsulated?

Humoral encapsulation consists of the formation of capsule material such as melanin without participation of blood cells. This type of defense reaction is restricted to certain Dipteran larvae but may be important for elucidation of general events. Evidence has been accumulated that provocation of the phenoloxidase cascade could represent a key mechanism in the reaction to foreign objects and their enclosure into capsule material.

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Encapsulation of parasites and pathogens in insects sometimes occurs without direct participation of blood cells. So far it has been observed only in dipterous larvae with few circulating blood cells.

This reaction of "humoral" or "cell free" encapsulation is triggered by parasitic nematodes. Bacteria and fungi are also rapidly and efficiently encapsulated in the hemolymph of chironomid larvae, as well as certain non living foreign bodies.

Humoral encapsulation occurs not only in the haemocoel but also in the cuticle invaded by fungal hyphae.

The reproduction of a such defence mechanism in in vitro conditions has allowed to study its mechanism in detail and to follow the effect of different factors.

Humoral encapsulation is based upon activation of phenoloxydase, and the capsule represents a polyphenol-protein complex.

S18.1.  
12

## NEMATODE-INDUCED ENCAPSULATION MECHANISMS

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Five categories of insect responses to nematode parasitization are recognized: (1) Simple encapsulation, (2) Melanotic encapsulation, (3) Humoral melanization, (4) Intracellular melanization, and (5) Tissue responses. Examples of each type will be discussed; however, emphasis will be given to Melanotic encapsulation and Tissue responses. Parasitization of muscoid fly larvae by the nematode, Heterotylenchus autumnalis, will be discussed with respect to the cellular, melanotic encapsulation response of the fly larva. The tissue response of Musca adult flies to nematodes (Habronema and Thelazia sp.) and the formation of parasitic capsules by the host will be discussed in detail. Ultrastructural studies revealed the formation of a "macrocell" that houses the nematode and is composed of organelles that function for the benefit of the parasite. Insect hemocytes are believed to produce a basal lamina surrounding the "macrocell" which the insect now recognizes as self and fails to elicit further hemocytic responses. A new cellular organelle, annulate lamella, never reported for a cellular defense reaction in insects is discussed.

P18.-  
1

## RECOGNITION OF CRUSTACEAN HEMOCYTES TO FOREIGN MOLECULES.

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The prophenoloxidase activating system (proPO) has been proposed to constitute a recognition system in arthropods, since it is specifically activated by beta-1,3-glucans (fungal carbohydrates) or lipopolysaccharides. Crustaceans have been found to react to injected beta-1,3-glucans, but not to other injected glucans by forming cell clumps and as a result a significant decrease in total hemocyte count (Smith, Söderhäll and Hamilton 1984, Comp. Biochem. Physiol. in press). Therefore, the hemocyte can recognize minute amounts of a foreign polysaccharide and in in vitro monolayers of pure hemocyte populations beta-1,3-glucans or LPS will cause degranulation of semigranular and granular cells, which contain the proPO-system. Also,  $\text{Ca}^{2+}$ -ionophores will degranulate the granular cells and, accordingly, a possible mechanism for the degranulation induced by the foreign molecules is an increase in the intracellular  $\text{Ca}^{2+}$  concentration which leads to the secretion of the granules containing the proPO-system by exocytosis.

P18.- SYMBIOTIC BACTERIA IN DACUS OLEAE: SUBMICROSCOPIC IDENTIFI-  
2 CATION OF THE TRANSMISSION MECHANISM

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In order to clarify the transmission mechanism of symbiotic bacteria in Dacus oleae, we examined by scanning and transmission electron microscopy (SEM and TEM) the alimentary canal, the Malpighian tubules, the female reproductive apparatus including ovipositor, and deposited eggs.

Bacteria pass from the upper oesophageal diverticulum, where they are stored and multiply actively, to the lumen of midgut where they gather and then to the rectum. In addition to these region of the alimentary canal, the bacteria are found in diverticuli that communicate with the lumen of rectum. No bacteria were found in the Malpighian tubules, in the anterior of the hind-gut up to the rectal ampulla, in the female genital apparatus, or in the haemolymph, the latter believed by some authors to be the vehicle by which bacteria pass from one region to another.

Results obtained may be helpful in the biological and genetic control of D. oleae and other members of Trypetidae.



Section 19    **Biological Control** .....

R 19.1.    *Biological Control in Practice* .....

R 19.2.    *Effectiveness of Natural Enemies* .....

R 19.3.    *Development of Techniques for Biological Control* .....

R 19.4.    *Population Dynamics of Natural Enemies* .....

R 19.5.    *Occurence of Natural Enemies* .....

R 19.6.    *Activity and Behaviour of Natural Enemies* .....

R 19.7.    *Biology of Natural Enemies* .....

S 19.1.    *Trichogramma and Other Egg Parasites* .....

S 19.2.    *Development and Operation of an International Bio-Control Network ...*

W 19.3.    *Trichogramma and Other Egg Parasites, a New Global IOBC*  
            *Working Group* .....

W 19.4.    *Workshop of International Heliothis Biological Control Working Group*

P 19.       .....

## **R19.1.** ACTIVITIES OF THE IOBC IN BIOLOGICAL AND INTEGRATED CONTROL

**1**

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The main objective of the IOBC, notably its West Palearctic Regional Section (WPRS) is to foster international collaboration in biological (BC) and integrated pest control (IPC). It does this mainly through Working Groups which establish joint international programmes of work as well as enabling scientists in particular fields to discuss common interests.

At present the WPRS has over 20 Working Groups dealing with particular pest or crop protection problems, for example the Working Groups on cereals and on vines, or Groups dealing with particular technologies such as use of pheromones or of models, or topics such as testing effects of pesticides on beneficial species.

The paper will give examples of work in progress and also outline other activities. It will highlight future developments for example on the cropping systems approach to pest control and on practical adoption of IPC technologies.

## **R19.1.** BIOLOGICAL CONTROL OF MOSQUITOES AND CHIRONOMIDS BY HABITAT REDUCTION AND PREDATION BY CICHLIDS

**2**

E. F. LEGNER

Division of Biological Control, University of California Riverside

The introduction and establishment of three species of African cichlids in California for the biological control of mosquitoes and aquatic midges are outlined. Population trends and reproduction of these fish and their impact on the aquatic ecosystem are detailed. Economic benefits to state departments responsible for the delivery of irrigation water by aquatic weed reduction, and to noxious aquatic insect abatement districts by precluding the need for insecticide applications are illustrated. The fish flourish in south California without management, giving excellent biological control of chironomids, mosquitoes and aquatic weeds, and constitute a significant game fishery.

**R19.1.** ATTEMPTS TO USE ALIEN PARASITES FOR THE CONTROL OF NATIVE PESTS IN  
**3** CANADA

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Biological control of native pests is seldom considered although there is growing evidence that such pests are equally amenable to control by introduced natural enemies of related hosts living under similar environmental conditions.

North American Phyllotreta spp. on crucifers are attacked by the braconids Microctonus spp. like in Europe but lack an ecological homologue of the Palearctic Townselitus bicolor which in Europe is the most effective parasite of the adult host stage. Introductions of this species are under way.

Analyses of the parasite complexes of Mamestra configurata in Canada and Mamestra brassicae in Europe show great similarities, but the parasitological niche filled by Microplitis mediator developing in young larvae of M. brassicae in Europe is without a counterpart in North America. This species is being tested as potential biocontrol agent in Canada.

**R19.1.** ESTABLISHMENT OF TWO PARASITIC WASPS INTRODUCED FROM PEOPLE'S  
**4** REPUBLIC OF CHINA TO CONTROL ARROWHEAD SCALE IN JAPAN

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Two chinese species of Hymenopterous parasites were introduced into Japan by Shizuoka Citrus Exp. Stn. and Fruits Tree Research Stn. in 1980, for the control of the Arrowhead Scale, Unaspis yanonensis Kuwana in citrus groves.

Both of Aphytis yanonensis DeBach & Rosen and Phycus fulvus Compere & Annecke became established in several districts, and highly effective in control of Arrowhead Scale in citrus groves.

Evaluation of both parasites as natural enemies against Arrowhead Scale will be discussed.



**R19.1.** "SCOPE AND PROSPECTS OF THE COMMERCIAL USE OF  
**5** TRICHOGRAMMA IN THE U.S.A."

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% Biogenesis, Inc.  
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Recent scientific and technological advances in mass rearing, storage, transportation, and release of Trichogramma sp. have contributed to greater availability of the parasite in the U.S.A. Better education and communication to growers by researchers, educators, extension personnel, and commercial companies has increased grower awareness and improved his acceptance of biological control of insect pests in some major cropping areas. The current few hundred thousand acres of crops annually receiving releases of natural enemies appears to have potential for significant expansion in crops such as cotton and corn in certain geographical areas. This expansion would be based upon the premise of: (1) continued scientific exploration into the biology of the parasite, certain key pests, and their interaction within the ecosystem in which they live, and (2) intensified efforts toward educating and communicating to growers the benefits of biological control by augmentation of natural enemies.

**R19.1.** THE PRACTICAL USE OF TRICHOGRAMMA TO CONTROL THE EUROPEAN  
**6** CORN BORER IN THE FEDERAL REPUBLIC OF GERMANY

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The area treated with Trichogramma evanescens Westw. to control the European corn borer Ostrinia nubilalis Hübner has increased in the Federal Republic of Germany from 300 ha in 1980 to 1800 ha in 1983, with increasing tendency. Reductions in the number of Ostrinia larvae of 75 and 95 % are achieved. Techniques used for the mass-production, quality control and application are given and problems with determining the appropriate time of treatment and the number of releases are discussed.

## R19.1. THE USE OF ENCARSIA FORMOSA TO CONTROL THE GREENHOUSE WHITEFLY IN 7 EUROPE.

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The greenhouse whitefly is the first greenhouse pest for which a successful biological control program was developed. Since 1927 the hymenopterous parasite Encarsia formosa has been used for controlling this pest. Although the availability of 'modern' insecticides caused a temporary decrease in the use of Encarsia formosa, several advantages of the use of this parasite above the use of insecticides resulted in a renewed application of the parasite. From 1968 to 1978 a strong increase in its applications was observed. Since then the total area on which Encarsia is applied levelled off. Causes for this, as well as other biological ways of controlling the greenhouse whitefly will be discussed. Further the role of I.O.B.C. working groups in organizing the research on biological control in greenhouses will be described.

## R19.1. INTRODUCTION STRATEGIES FOR PREDATORY MITES TO CONTROL 8 THRIPS IN GLASSHOUSES

P.M.J. RAMAKERS

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Biological thrips control on cucumber and sweet pepper by introduction of the predatory mites Amblyseius mckenziei or A. cucumeris was demonstrated to be possible in six successive years. The method became more practicable by the development of an efficient mass rearing method on storage mites as substitute hosts. Different methods of predator introduction were compared, including introduction previous to thrips occurrence, using the ability of these polyphagous Phytoseiids to survive in the presence of spider mites.

**R19.1.** Biological control of the leafminers Liriomyza bryoniae and  
**9** L.trifolii on greenhouse tomatoes in Western Europe

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The tomato leafminer, Liriomyza bryoniae Kalt. (Dipt.Agromyzidae), is a common pest in greenhouses of Western Europe and occurs more frequently since 1976, mainly on tomatoes. There are some native parasites which can occur spontaneously and can provide natural control: the braconid endoparasites Dacnusa sibirica Telenga and Opius pallipes and the eulophid ectoparasite Diglyphus isaea Walker. Introduction methods have been developed for the latter two, but cannot be applied because of infestations on tomatoes by the introduced L.trifolii Burgess in many countries since 1980. Candidates for biological control of both Liriomyza species are investigated: the European D.isaea, the eulophid endoparasite Chrysocharis parksi (Crawford) from California and an Opius species from Ohio. D.sibirica and O.pallipes are not good candidates for control of L.trifolii.

**R19.1.** BIOLOGICAL CONTROL OF INSECT PESTS IN THE AZORES ISLANDS  
**10**

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PROFESSOR OF BIOLOGICAL CONTROL  
UNIVERSITY OF THE AZORES - 9500 PONTA DELGADA - PORTUGAL

Some Azorean insect pests are subject of biological control programmes. Among *Lepidoptera*, the pasture army-worm *Mythimna unipuncta* is currently under *Trichogramma* and *Apanteles* control measures. *Sesamia nonagrioides* on *Strelitzia* and *Noctua pronuba* on vineyards are also considered as targets for similar R.D. operations.

The Japanese beetle, *Popillia japonica*, introduced in Terceira Island by 1960 through the U.S. Air Force Base is spreading inland.

Chemical control has been useless and biological control alternatives are presented.

Aphidophagous Coccinelids, its mass rearing, use and introduction of exotic species are also discussed. Results and perspectives are given for all these research lines.

R19.2.  
1

## OVIPOSITION BEHAVIOR AND HOST REGULATION BY EGG PARASITIDS

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The oviposition behavior and kairomones that influence egg parasitoids will be discussed. The role played by chemicals as well as shape and texture will be discussed.

In addition to the factors involved in host selection, the effects of parasitoids on the host egg will be examined. The sources and nature of the egg regulation factors and their ecological significance will be discussed.

R19.2.  
2

## BIOLOGICAL CONTROL OF PHYCITIDS IN SOFT-SHELLED ALMONDS

E. F. Legner

Division of Biological Control, University of California Riverside

The acquisition, culture and establishment of parasitoids of the navel orangeworm, Amyelois transitella, and carob moth, Ectomyelois ceratoniae is detailed. Separate k-value analyses in soft-shelled almond orchards where two bethylid parasitoids were established indicate significant host regulation during warm summer seasons. No regulation by any species of parasitoid was detected during cool seasons to date, although a long-established Pentalitomastix plethoricus may fill this vacant niche. The need for continued widespread dissemination of two bethylids, Goniozus emigratus (biparental strain), and Goniozus legneri is apparent, and the search for efficient natural enemies of carob moth in Australasia may be a good biological control strategy.

**R19.2.** EVOLVED INTERSPECIFIC HOMEOSTASIS AFFECTS THE SUCCESS OF  
**3** BIOLOGICAL CONTROL

Dr. HEIKKI HOKKANEN

Cornell University, NY, USA (now at Kuopio University, Finland)

Interspecific homeostasis refers to the state of ecological equilibrium between populations of interacting species, brought about by evolutionary processes. In three separate studies the author has concluded that

1) Probably the majority of world's most threatening plant diseases involve a host-pathogen relationship in which an ecological equilibrium has not been able to evolve. Such relationships appear thus to be very destructive.

2) In introducing natural enemies for biological control, parasites (including predators), which lack evolved interspecific homeostasis with the target pest, proved to have about 80% greater chance of success than parasites which have a long coevolutionary history with the pest species.

3) Populations of Nezara viridula and Trichopoda pennipes have evolved towards interspecific homeostasis during those 150-200 years, which they have been interacting in tropical America. Comparing to the initial situation, the reproductive success of the host has increased in this time by at least 10%.

These findings imply that in the search for most effective natural enemies of pests we should focus attention on species which have not had a chance to evolve the state of interspecific homeostasis with the target pest, i.e. to search in other faunistic regions than the native area of the pest.

**R19.2.** CONTINUED DECLINE AND REGULATION OF OLIVE PARLATORIA SCALE  
**4** BY TWO INTRODUCED APHELINID PARASITOIDS

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Sampling done in recent years compared with data taken in the 1960s reveals a continuing marked decline of Parlatoria oleae from an already low density. The two parasitoids, Aphytis paramaculicornis and Coccophagoides utilis continue to co-exist at extremely low densities of the host. Each continues to have an important role. The action of Aphytis has presented a density-dependent regulatory relationship but such is not evident for Coccophagoides, although this latter species continues to contribute a high and necessary host mortality in the process of maintaining the high degree of economic biological control by the two parasitoids acting concurrently.

**R19.2.**  
**5** PRELIMINARY DATA ON THE INFLUENCE OF THE PREDATUS STETHORUS  
PUNCTILLUM (WEISE) ON PANONYCHUS ULMI (KOCH)

P. PAPAIOANNOU - SOULIOTIS

BENAKI PHYTOPATHOLOGICAL INSTITUTE, KIPHISSIA-ATHENS GREECE

The importance of the Coccinellid Stethorus punctillum (Weise) as predator of various species of the plant-feeding mites of the family Tetranychidae has been observed for many years both in the field crops and the greenhouses.

Data on the process of the infestation of the apple trees by Panonychus ulmi (Koch) and the population densities of S. punctillum have shown the relation between the predator species and P. ulmi.

The application of some insecticides against various enemies of the apple trees reduced considerably the population densities of S. punctillum. This established an unbalanced biological relation between the predator and the mite and resulted high population densities of P. ulmi.

Also, it was observed that S. punctillum has three generations annually.

**R19.2.**  
**6** EXPERIMENTS ON THE USE OF NEMATODES FOR THE CONTROL  
OF CEPHALEIA SP.

HENRYK SANDNER

Warsaw Agriculture University, Poland

On the area of the one of the National Parks in Carpathian Mountains the biological control of Cephaleia sp. using the invasive larvae of Neoaplectana carpocapsae Weiser and Heterorhabditis bacteriophora Poinar nematodes was carried out. Invasive larvae were placed in moist sawdusts on the soil of fir stands infested by the pest in 5 m intervals. This treatment took place when the Cephaleia larvae entered the soil. The effectiveness of the treatment was estimated in autumn while determining the mortality of insect larvae and the presence of nematodes in their body cavity.

**R19.3.** MORPHOLOGICAL AND PHYSIOLOGICAL DIFFERENCES IN *NEOAPLECTANA CARPOCAPSAE*  
**1** LARVAE REARED IN *GALLERIA MELLONELLA* AND *SITOPHILUS GRANARIUS*

M. A. ALIKHAN, A. BEDNAREK <sup>\*(1)</sup> AND S. GRABIEC <sup>\*(2)</sup>

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Canada

Studies on the metabolic activity (measured by the Chemiluminescence method involving pyrogallol oxidation) and the measurements on the membrane potential (Powder Electrode technique) have shown that *Neoaplectana carpocapsae* invasion-stage larvae, reared on *Sitophilus granarius* adults were twice more active than those reared in *Galleria mellonella* larvae. In addition, these two entomogenous nematode larval populations showed significant morphological differences.

The significance of these findings will be discussed.

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**R19.3.** The Release of *Lixophaga diatraeae* townsend while in its pupal stage,  
**2** and some Aspects Favoring or Limiting it.

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Research Institute of Plant Protection, Playa, Havana, Cuba

A study was made of the effect of biotic and abiotic factors an *Lixophaga diatraeae* released while in its pupal stage, taking into account three periods prior to the emergence of the adult (24, 48 and 72<sup>h</sup>). For each of the pupal ages, three replicates of 50 individuals each were made, and those were released in waxed paper bags with holes previously punched out and hung between two successive sugarcane stalks in the rows by strings smeared with grease as isolating material. These bags were brought back to the lab twelve days later. The analysis of the results consisted in comparing the percentage of emergence for each of the studied variants. No significant differences were observed between the percentages of pupal emergence during the 24 and 48 hours periods before adult emergence, but there were some between the latter and the 72 hours one. The mean percentages of emergence in 24, 48 and 72 hours were 86.79; 82.38 and 74.37 respectively. The interaction between the pre-emergence periods during the different months the experiment has lasted did not show any significant difference. It is recommended to carry out the releases with pupae 24 to 48 hours before the adults emerge. There is here coincidence with other authors about the advantages offered by the release of this predator while in its pupal stage, with use of waxed paper bags, because it allows to do without the otherwise necessary handling of bulky cages, and to limit it exclusively to rearing of stock insects, and to the work related with rearing, sexing and reproducing this Tachinid.

219.3.  
3

### OPTIMIZATION OF TIMING OF LOBESIA BOTRANA SCHIFF: CONTROL

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*Lobesia botrana*, a dangerous pest, is widely spread in vine-growing regions of the Georgian SSR. High harmfulness is conditioned by polyvoltinity of the species and its latent mode of life. In Georgia *Lobesia botrana* has three generations. Chemical preparations are applied against the first and second generations. The optimal date for *Lobesia botrana* control is appearance of the first aged larvae - vulnerable phase for the chemical preparations. Because of the specific ecological peculiarities this phase has short period. The effectiveness of protective measures is determined by this date precise forecasting.

The pheromone traps with grapamone (3-5 traps per hectare) for signalling of flight timing of pest moth and phenoprognostic calendars calculated by the method of interpolation with the help of regressive equations permitted to optimize the timing of *Lobesia botrana* control and increase effectiveness of protective measures.

R19.3. POSSIBILITIES FOR BIOCONTROL OF SESAMIA SPP. (LEP. NOCTUIDAE)  
4 BY EGG PARASITIDS (HYMENOPTERA)

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Sesamia spp. lay their egg masses between the leaf blade and the stem of cultivated and wild Gramineae.

In such a microhabitat, some species of Telenomus Hal. (Scelio-nidae), previously described as Platytelenomus Dodd on account of their flat body, seem to be fairly effective in controlling these noctuids.

Trichogrammatidae have also been recorded in a few cases but their potential is questionable.

Information from literature is reviewed and some indications on the possibilities offered by Telenomus spp. are given.



**R19.4.** HOST DENSITY EFFECTS ON THE BEHAVIOUR OF THE APHID PARASITOID  
**1** APHIDIUS NIGRIPES.

CONRAD F. CLOUTIER

Département de biologie, Université Laval, Ste-Foy, Québec, Canada, G1K 7P4.

In laboratory tests, the solitary aphid parasitoid A. nigripes exhibits a type II functional response to the density of its host, Macrosiphum euphorbiae. However the egg production per female is not affected and consequently superparasitism increases with decreasing host density. A search for factors causing superparasitism indicated that female A. nigripes systematically lay > 1 egg/host when the host density is well below the parasitization potential of one parasitoid. Host discrimination tests indicated rejection of already parasitized hosts builds up slowly to reach a maximum of ca. 90% 24 h after initial parasitization. The ecological significance of these findings will be discussed.

**R19.4.** TREND IN THE POPULATION DEVELOPMENT OF CASSAVA  
**2** MEALYBUG AND ITS PREDATOR

DR (MRS) ETHEL-DORIS N. UMEH

ANAMBRA STATE UNIVERSITY OF TECHNOLOGY, PMB 01160 ENUGU, NIGERIA

The population development of the cassava mealybug, Phenacoccus manihoti (Pseudococcidae) and its local predator, Hyperaspis marmottani (Coccinellidae) was monitored during 1980/81 and 1981/82 growing seasons.

The population development of P. manihoti followed a pattern determined principally by rainfall and natural enemies. Although found in the field all round the year, high densities of P. manihoti were reached only in the dry season, during the later part of which period its population was also annihilated by natural enemies.

Hyperaspis marmottani was found in the field mainly in the dry season when the population of P. manihoti had been established. Although primarily responsible for the collapse of P. manihoti population towards the end of the dry season, H. marmottani was unable to control its prey population in good time to prevent damage to cassava plants. Its inability to achieve early control of P. manihoti stemmed from the fact that its own larval parasitoid, Metastenus sp. suppressed its population until high densities of P. manihoti were reached and hence provided effective microhabitats for H. marmottani larvae.

219.4. PARASITIZATION OF THE SUGARCANE GIANT BORER  
3 PHRAGMATOECIA GUMATA SWINHOF IN MALAYSIA

LIM. G.T.

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Eggs of the sugarcane giant borer Phragmatoecia gumata Swinhof were collected from the fields and held in laboratory to determine the levels of parasitization by Tumidiclava sp (Hymenoptera: Trichogrammatidae). Mean percentage of parasitization was  $38.81 \pm 4.56$  (range: 20.62 - 51.93),  $56.22 \pm 7.51$  (range: 17.84 - 92.26),  $34.98 \pm 5.60$  (range : 4.13 - 56.16) and  $46.25 \pm 4.09$  (range: 28.92 - 64.94) in 1977 to 1980 respectively.

The influence of rainfall and temperature on the field parasitization is discussed.

R19.4. CAMPOLETIS CHLORIDEAE UCHIDA (ICHNEUMONIDAE) A PROMISING  
4 ENDOPARASITOID OF HELIOTHIS ARMIGERA (HUBNER)(NOCTUIDAE)

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Aurangabad 431 004, India.

The present findings deal with Campoletis chlorideae Uchida (Hymenoptera, Ichneumonidae), a larval endoparasitoid of Heliothis armigera (Hubner) (Lepidoptera, Noctuidae). This parasitoid develops between  $10 \pm 1^{\circ}\text{C}$  to  $38 \pm 1^{\circ}\text{C}$ . With 20% honey, a suitable food, males survived for 13.20 days and females for 10.82 days. The maximum mean progeny production per female per day was 2.2, the innate capacity of increase was 0.130 and population multiplied 15.84 times in mean generation time of 21.25 days. These and other known data convince C. chlorideae as a promising endoparasitoid for biological control of noxious H. armigera.

R19.5.  
1

PREDATORS OF THE BROWNPLANTHOPPER, *NILAPARVATA LUGENS* STAL  
AND ITS PREDATING POTENCY.

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Bogor Research Institute For Food Crops, Indonesia

From 1970 up to 1976 the brownplanthopper, *Nilaparvata lugens* was the most important pest in Indonesia damaging huge area of rice by direct feeding and indirect by transmitting grassy stunt and ragged stunt virus. The pest is now under control, but due to many factors stimulating the outbreak it still consider as a potential pest. Search for natural enemies of the brownplanthopper lead to the identification of predators, such as myrid bug, *Cyrtorhinus lividipennis*, carabid weevil, *Casnodea interstitialis* Subba Rao, Staphylinid, *Paederus tamulus*, Coccinellid, *Coccinella arcuata*, veliid, *Microvelia* sp. and spider (under identification). Laboratory studies was initiated to determine the predatory potential. *C. lividipennis* with the highest ratio of predator to host 1 to 20 consumed 2 hopper a day. *P. tamulus* and *C. interstitialis* fed with 20 hoppers per rice hill, being the highest density, consume repectively 8 and 9 hoppers daily. The spider has a predating potency of 3 hoppers a day equal to *C. arcuata*. Looking to the multiplication rate of the female brownplanthopper ranging from 100-500 progeny and the capability of predation of individual predator, they are important at low density level of hopper population. At high density the incorporation of insecticide with low toxicity to the predators is urgently needed.

R19.5.  
2 THE ROLE OF PARASITIC NEMATODES IN THE POPULATION DYNAMICS OF  
*PHAULACRIDIMUM VITTATUM* (SJOSDT.) (ORTHOPTERA : ACRIDIDAE).

BAKER, G.L.

N.S.W. Department of Agriculture, Rydalmere. N.S.W. Australia.

Outbreaks of wingless grasshopper, *Phaulacridium vittatum* occur every 4-6 years in South-Eastern Australia and result in severe damage to improved pasture.

Parasitism by a complex of endemic mermithid nematodes was the key factor influencing *P. vittatum* numbers between 1979-1983. *P. vittatum* numbers and the level of parasitism followed a sequential pattern of increase and decline. Synchronisation of the host-parasite cycle due to changes in land use resulted in localised outbreaks which entered a recession when land use heterogeneity was restored. Below average rainfall at the start of a season reduced nematode activity resulting in regional outbreaks which declined following widespread rain. The intensity of regional outbreaks was a function of both land use heterogeneity and rainfall.

The phasing of land use changes in a manner which maximises heterogeneity may be a possible method of preventing localised outbreaks and reducing the intensity of regional outbreaks.

**R19.5.** SOME SOUTH INDIAN COCCOIDS OF ECONOMIC IMPORTANCE  
**3** AND THEIR NATURAL ENEMIES

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In South India major coccoid pests like Coccus viridis, Planococcus citri and Saissetia coffeae and occasional species such as Chloropulvinaria polygonata, Rastrococcus iceryoides, Nipaecoccus viridis and Pseudococcus longispinus occur on many cultivated and wild plants. Others, for example Ceroplastes floridensis, Coccus hesperidum and Russelaspis pustulans, known to be pests elsewhere have also been recorded. Parasaissetia nigra was the most polyphagous species collected by the authors.

Of the primary parasites reared the Encyrtidae are more conspicuous than the Aphelinidae and other groups in terms of genera and species. Coccophagus cowperi (Aphelinidae) has a wide host range. Marietta javensis (Aphelinidae) and Tetrastichus purpureus (Eulophidae) are hyperparasites. Among the predators Chilocorus nigritus and Scymnus coccivora are common.

**R19.5.** POTENTIAL NATURAL ENEMIES FOR BIOLOGICAL CONTROL  
**4** OF INSECT PESTS IN UAE

SAEED A. BA-ANGOOD

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P O BOX 6172 PDR OF YEMEN

The first survey of natural enemies of insect pests in the United Arab Emirates started last year. So far we collected more than 20 species of predators and parasites. Studies were carried out on food consumption and life history for some of them, in the laboratory and the green house. Field collection of aphids showed that the percentage of aphids parasitized by Aphelinus sp and Aphidius sp ranged from 5 to 30% in different areas of UAE. Calosoma sp consumed 1-2 grasshoppers, 2-6 maggots and grubs and 1-2 crickets, per day. Each larva and adult of Coccinella 7-punctatum consumed 4-31 and 3-7 aphids per day, respectively, while Chrysopa sp larva consumed 4-40 aphids per day. Observations on the behaviour of Sphex ichneumoneus showed that there were 6-14 nests in 10m<sup>2</sup> shelter. Each nest consists of 2-23 cells and the number of Caterpillars (Spodoptera spp) in each cell ranged from 2-9 larvae. Studies on the biology of this predator showed that the duration from egg laying to adult emergence took 25-45 days. Tachinids, dragon flies, antlions, earwigs and mantids were also recorded.

**R19.5.** PARASITE COLLECTIONS FOR BIOLOGICAL CONTROL OF AUTOGRAPHA SPP.

**6**

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EUROPEAN PARASITE LABORATORY, ARS, USDA, IA  
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Parasites collected around Paris, France, attacking Autographa gamma L., a noctuid pest of alfalfa, included several species of Ichneumonidae, Braconidae, and Encyrtidae. These species are being identified at the time of preparation of this abstract. The most promising of these natural enemies is the encyrtid, Ageniaspis fuscicollis (Dalman), based on its high field populations, frequency of attack, and good timing of attack, overwintering as a larval endoparasite and killing the host early the next season. Although this parasite could be of interest to introduce into the U.S., encyrtids already attack Autographa californica (Speyer) there, and comparative evaluation of the parasite species would be needed prior to importation of the European species.

**R19.5.** PARASITISM OF STINK BUG<sup>a</sup> EGGS IN SOYBEAN FIELDS IN SOUTHERN LOUISIANA

**7**

<sup>a</sup>Hemiptera: Pentatomidae

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<sup>1</sup>Dept. of Entomology, Louisiana State University, Baton Rouge, LA 70803

<sup>2</sup>U.S.D.A., Stoneville, Mississippi

Parasitism of the eggs of Acrosternum hilare (Say), Edessa bifida (Say), Euschistus spp., Nezara viridula (L.) and Podisus maculiventris (Say) was studied. Naturally-oviposited egg masses were collected once weekly from soybean fields from July 21 to October 1 to determine the degree of parasitism. Seven parasite species were recovered with Trissolcus basalis (Wallaston) and Telenomus podisi Ashmead the most predominant. All parasite species except 2 Telenomus sp. were found in eggs of more than 1 host species. Trissolcus basalis was the only species to parasitize N. viridula egg masses singly; however 21% of parasitized N. viridula egg masses were juxtaparasitized by T. basalis and T. podisi. Pentatomid egg mortality due to parasitism ranged from 22.1% in A. hilare to 47.8% in Euschistus sp.

R19.6.  
1

CONSEQUENCES OF SCALE SIZE ON THE BIOLOGICAL CONTROL  
OF CALIFORNIA RED SCALE BY ITS PARASITIDS

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UNIVERSITY OF CALIFORNIA, RIVERSIDE, CALIFORNIA 92521 USA

Biological control of California red scale, Aonidiella aurantii (Maskell), varies in California depending upon the citrus cultivar inhabited by the scale and the citrus region in which the scale occurs. Several red scale parasitoids require the scale to be of a specific size or larger before they will allocate eggs to a scale. Sons are allocated to smaller scales than daughters and daughters to smaller scales than multiple eggs. However, scale size varies with substrate (wood, twigs, leaves and fruits) and the citrus region in which the scale occurs. Also, the number of scale generations and the degree of age structure expressed by the scale population depend upon the citrus region (climate) in which the scale occurs. These factors determine the timing and abundance of suitable scale stages available to the parasitoids for progeny production and thus determine the degree of biological control achieved.

R19.6.  
2

HOST RECOGNITION BY APHYTIS MELINUS AND A. LINGNANENSIS

NEDIM UYGUN, DEPT. PLANT PROTECTION, UNIV. CUKUROVA, ADANA, TURKEY, AND  
ROBERT F. LUCK, DIV. BIOLOGICAL CONTROL, UNIV. CALIFORNIA, RIVERSIDE USA

One component of the host finding-host selection process exhibited by a parasitoid is host recognition. Both Aphytis melinus DeBach and A. lingnanensis Compere (Hymenoptera: Aphelinidae) use kairomones to recognize California red scale, Aonidiella aurantii (Maskell) (Homoptera: Diaspididae). In both parasitoid species these kairomones are necessary for continued arrestment and initiation of drilling. Kairomones, however, are not the sole mediator of host recognition. Physical factors such as shape and texture of the host along with the ovarion state of the searching female parasitoid also appear to be important mediators.

**R19.6.** FUNCTIONAL RESPONSE OF PHYTOSEIID MITES

**3** IN RELATION TO PREY WEB STRUCTURES

HANS MORI & YUTAKA SAITÔ<sup>^</sup>

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Influence of tetranychid webbing habits on the functional responses of three species of predacious mites, Phytoseiulus persimilis, Amblyseius longispinosus and Amblyseius fallacis was studied at various densities of Tetranychus urticae in small cages placed on mulberry leaves.

The functional response curve for egg consumption rose with a continually decreasing slope to a plateau according to prey density increased. The sites of egg consumed by predators differ among phytoseiid species. Many egg were fed on prey web in P. persimilis compared with the other species.

The predacious behaviour of thre phytoseiids will be discussed.

**R19.6.** COMPARATIVE STUDIES ON THE FEEDING ACTIVITY OF THE PREDATORY MITE, Phytoseiulus persimilis ATHIAS-HENRIOT AND THE PREDATORY THRIPS, Scolothrips longicornis PRIESNER

**4**

SUSANNE GERLACH & CETIN SENGONCA

Institut für Pflanzenkrankheiten der Universität Bonn, W.Germany

In the laboratory studies on the feeding activity of Phytoseiulus persimilis and Scolothrips longicornis were conducted using Tetranychus urticae as prey. For both mite predators the daily number of T.urticae eggs and adults consumed were determined and the total prey consumption by immatures and adults of the two species were observed and compared.

R19.6.  
5

HISTOLOGY OF HOST-PARASITOID ASSOCIATION, HEDYLEPTA INDICATA-TOXOPHOROIDES SP.

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Entomology Department, CSAT-SARH, 86500 Cárdenas, Tabasco, México

The lepidopterous defoliator, Hedylepta indicata, is parasitized to the tune of 80% by a solitary parasitoid, Toxophoroides sp. (Hymenoptera: Ichneumonidae). Histological studies indicated that this internal parasitoid developed in the intestine of the host, apparently fed on the intestinal contents, and induced malnutrition in the preferred last instar host larva. It seemed not to feed on the host tissue itself. The parasite eggs deposited directly into the intestine developed, while those incerted elsewhere eventually degenerated through immune reaction of the host. Host specificity and compatibility in this case is revealed through an indirect phytophagy by the parasite on the intestinal contents where immune reaction is not possible. The host intestinal contents are obtained directly from the masticated and ingested plant tissue and seem to favor the hatching of the parasitoid egg and the development of the subsequent instars inside host intestine alone. The mortality of the host larvae is as a result of malnutrition, similar to the condition resulting from the vertebrate intestinal parasites.

R19.7.  
1 ON THE PHOTOPERIOD AND REFINE PRODUCTION OF MICROPLITIS RUFIVENTRIS KOK. (HYM., BRACONIDAE).

ESMAT.M. HEGAZI

Faculty of Agriculture, University of Alexandria, Egypt

The effect of constant temperatures: 30, 25 and 20 °C ± 1 °C combined with photoperiods of complete darkness (OL:24D), 6 hrs light and 18 hrs darkness (6L:18D), (12L:12D), (18L:6D) and continuous light (24L:0D) on the production of the solitary larval parasite Microplitis rufiventris Kok. using the non-diapaused host larvae of Spodoptera littoralis (Boisd.) was experimentally studied. The refine development of the parasite, i.e., the highest yield of parasite cocoons through the first 2 days of the emergence period from the parasitized host larvae is achieved under longday (18L:6D) and (24L:0D) at 30 °C; shortday (6L:18D) at 25 °C; and complete darkness (OL:24D) and shortday (6L:18D) at 20 °C. At 20 °C the photoperiod has considerably affected the developmental speeds of the egg-larval and pupal stage of the parasite.



**R19.7.** BIOLOGY OF THE PARASITE BRACON HEBETOR ON HIBERNATING  
**2** LARVAE OF THE EUROPEAN CORN BORER, OSTRINIA NUBILALIS

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Tanta University, Kafr El-Sheikh, Egypt.

The biology of Bracon hebetor Say on hibernating larvae of Ostrinia nubilalis (Hübner) was studied under constant condition. Developmental duration were 2.5, 9.1, 2.4 and 9.8 days for egg, larva, prepupa and pupa, respectively. Longevity was 34.1 and 11.0 days while total life-cycle amounted to 57.9 and 34.8 days for female and male, respectively. Fecundity averaged 203.4 and eggs hatchability was 94.8%. Number of hosts destroyed per female was 36.7 through oviposition and 86.4 through paralysation. The peak period of egg-laying and destruction of hosts was that of 8-9 days of age.

**R19.7.** HOST ASSOCIATIONS IN OOPHAGOUS PARASITIC HYMENOPTERA  
**3**

BIN F. (\*), STRAND M. R. & VINSON S. B. (°). (\*) Ist. Ent.agr.Univ. Perugia, Italy; (°) Dept.Ent.Texas A&M Univ. College Station, USA

Oophagous Hymenoptera have diverse host relationships, include a large number of species and are potential biocontrol agents.

Oophagy in the larval stage involves predation or parasitism which is by far the most common relationship. Predation by adults has also been recorded.

Oophages are represented in sixteen families three of which are entirely composed of egg parasitoids, Mymaridae, Trichogrammatidae and Scelionidae. The sixteen, except one, the Bethyloidea, which belongs to Aculeata, are grouped in five superfamilies within the Parasitica. Host relationships and associations at a family level are summarized in tables and briefly commented.

Some examples are described in detail to illustrate other aspects, such as host oviposition sites and egg characteristics, which are important for understanding oophage strategy.

**R19.7.**  
**4** ON THE THERMAL EFFECTS ON THE PARASITE MICROPLITIS  
RUFIVENTRIS KOK. AND ITS HOST SPODOPTERA LITTORALIS  
(BOIS.).

ESMAT M. HEGAZI

Faculty of Agriculture, University of Alexandria, Egypt

Effect of thermal treatment of 3, 35, and 40°C ± 1 of 1-3 days on the different parasite stages within host larvae, healthy host larvae and parasite adult females were studied. The insects were treated immediately or held before and after treatment at 25°C according to the testing schedule. The results revealed the following: a) 3°C: The parasite survived treatments but retarded development and moulting problems were observed. b) 35°C: Mortality records of parasite eggs inside hosts parasitized during their 2nd instar and different speeds of development among parasite larvae were recorded. c) 40°C: The egg-stage and the 1st larval parasite instar did not withstand the treatment and died while older parasite stages suffered from moulting failure, abnormal speeds of development and emergence problems. The duration of the larval stage of the healthy larvae prolonged for ca. 3 days as a result of 40°C treatment. All parasite adults perished at 40°C. Parasitization tendency and number of parasite eggs decreased when adult parasite females exposed to 35°C.

**R19.7.**  
**5** Investigations into the Reproductive Biology of Mesochorus  
nigripes Ratzburg (Hymenoptera: Ichneumonidae)

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Mesochorus nigripes Ratzburg is a hyperparasite which is present in both North America and Europe and attacks Bathyplectes stenostigma (Thomson) and B. curculionis (Thomson), which in turn are parasites of Hypera postica (Gyllenhal). In North America, M. nigripes reproduces thelytokously, while in Europe an expected 1:1 sex ratio is found. Three collections of this hyperparasite were made in southern Sweden in 1978, 1981 and 1982. Laboratory rearing tests failed to disclose the presence of a thelytokous form of M. nigripes in southern Sweden, and the question of whether the two populations are conspecific remains unresolved.

## **S19.1.** TRICHOGRAMMA REARING AND RELEASE TECHNOLOGY IN THE USA

**1**

RICHARD K. MORRISON

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The methods used in the USA for the mass production of Trichogramma pretiosum Riley and its laboratory host, the Angoumois grain moth Sitotroga cerealella (Olivier) are presented. Also, the methods used to prepare the parasitoid for aerial release, along with the release device are discussed.

## **S19.1.** MASS-PRODUCTION AND FIELD APPLICATION OF Trichogramma maidis PINTUREAU

**2**

ET VOEGELE AGAINST THE EUROPEAN CORN BORER IN SWITZERLAND

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A mass-rearing of Trichogramma maidis started 1978 in Switzerland in view of field applications against the European corn borer, Ostrinia nubilalis, on maize. With an increasing tendency from 1978 to 1983, the seasonal production reached in 1983 140 million adults of this egg parasite which allowed the treatment of almost 1000 ha. In intervals of 7 days three releases of 150'000 adults per ha and generation resulted in an average larval reduction of 75-90 %. To obtain an equal control with one or two releases only, different developmental stages of the egg parasite have to be mixed before releasing. Toward other rationalisations a more efficient egg-production of the Mediterranean flour moth, Ephestia kuehniella Zell. was developped.

**19.1.** FACTORS INFLUENCING INUNDATIVE RELEASES OF TRICHOGRAMMA MINUTUM  
**3** FOR BIOLOGICAL CONTROL OF THE SPRUCE BUDWORM.

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Inundative releases of Trichogramma minutum Riley for biological control of the spruce budworm, Choristoneura fumiferana (Clemens), were investigated in Canada's boreal forest during 1982 and 1983. The most significant factors affecting the level of egg parasitism were the time of release, the density of the parasite, and the local weather conditions. Food supply to the parasite, vertical location of the host egg mass in the stand, and density of the host insect were less important. Parasitism was not affected by the tree species on which budworm egg masses were laid. Fecundity, longevity, emergence, sex ratio of the progeny, and the number of non-fecund females were compared in the laboratory for strains of T. minutum from different geographical origins. The origin of the strain was not considered as important for subsequent releases as the rearing conditions because of the high degree of individual variation within each strain.

**S19.1.** THE BEHAVIOURAL ECOLOGY, RESISTANCE TO PESTICIDES AND  
**4** IN VITRO REARING OF TRICHOGRAMMA JAPONICUM IN CHINA

LI LI-YING LIU WEN-HUEI LI KAI-HUANG GUO MIN-FANG

Guangdong Entomological Institute, Guangzhou, Peop. Rep. China

Trichogramma japonicum Ashmead is an indigenous dominant egg-parasite of lepidopterous pests in the paddy fields of China. It is mass reared to control Cnaphalocrocis medinalis Guenée in Guangdong, Guangxi Provinces, and Chilo suppressalis (Walker) in Yuengnan Province of China. The eggs of Corcyra cephalonica (Stainton) are used as factitious host for mass production. In this paper, the biology of reproduction, discrimination of parasitized and unparasitized hosts, intra- & interspecific competition, host-parasite population relationship, resistance to pesticides, and in vitro rearing of Trichogramma japonicum are discussed.

**519.1.** SUPPRESSION OF STORED-PRODUCT MOTH POPULATIONS  
**5** BY RELEASE OF TRICHOGRAMMA

JOHN H. BROWER

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Eggs of stored-product moths, such as Sitotroga cerealella (Olivier), Anagasta kuehniella (Zeller), and Corcyra cephalonica (Stainton), are often used for the mass rearing of Trichogramma spp. In Georgia, Trichogramma spp. naturally attack eggs of Cadra cautella (Walker) in commercial peanut storages. Tests in simulated peanut storages showed that inundative releases of T. pretiosum Riley may greatly suppress stored-product moth populations. The amount of population suppression varied, up to a maximum of 57%, depending on numbers released and frequency of release.

**519.1.** MANAGEMENT OF HELIOTHIS SPP. IN COTTON BY AUGMENTATIVE  
**6** RELEASES OF TRICHOGRAMMA PRETIOSUM

E. G. KING, L. F. BOUSE, D. L. BULL, W. A. DICKERSON, W. J. LEWIS, P. LIAPIS, J. D. LOPEZ, R. K. MORRISON, AND J. R. PHILLIPS

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Release of Trichogramma pretiosum in cotton for control of Heliothis spp. resulted in increased egg parasitism; often averaging about 30 to 60% between fields. Moreover, beneficial arthropod populations were higher in release or non-insecticide fields than in cotton fields treated with insecticide. Larval parasitism averaged 30 to 50% during 1981 and 1982, respectively, in Arkansas; but was less in North Carolina. Nevertheless, Heliothis spp. were not maintained below subeconomic levels 2 of the 3 years of parasite release; and Heliothis spp. populations were generally low the third year. Insecticide treatment for other pests, particularly the boll weevil, was a major impediment to testing the technology. The ability to mass produce, program, and release the parasite was demonstrated.

**19.1.7** FIRST TRIAL IN INONDATIVE RELEASE OF TRICHOGRAMMA MAIDIS FOR CONTROL OF OSTRINIA NUBILALIS IN NORTHERN ITALY.

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Population dynamics of Ostrinia nubilalis Hb., European corn borer, were studied in the vicinity of Bologna in 1983 to determine the oviposition period of this pest and distribution of eggs within the crop. Temperatures were recorded and adult moths were caught in pheromone traps.

Two flight periods were clearly demonstrated. The first, from May 26 to June 27 was small in number, the second flight, from August 1 to September 1 was much larger. Few egg masses were present following the first flight, many after the second. From 9 releases of Trichogramma maidis Pintureau and Voegelé (May-August) the parasite effectively controlled eggs of the first generation but gave inadequate control of the second.

In 1982 and 1983 wild T. maidis specie samples, collected far off the release fields, were examined and populations of T. maidis were present in all areas sampled.

**19.1.8** FIELD EXPERIENCES WITH TRICHOGRAMMA AGAINST EUROPEAN CORN BORER (OSTRINIA NUBILALIS HB.) ON CORN IN NORTH EAST ITALY.

PAOLETTI, M.G.<sup>1</sup> & BERTONCELLO BROTTI, G. & ZECCHIN, F. & GANI, M. & PAOLETTI, M. & MORETTO, E.

<sup>1</sup>Dipartimento Biologia - Università di Padova.

Corn extensively cultivated in North East Italy was first introduced in the middle of XVI century and Ostrinia nubilalis Hb. was reported only at the beginning of XIX century and now is one of the main pests. Trichogramma maidis Pint. Voeg. (det. J. Voegelé) among biological control agents was easily found in the corn fields on the egg masses of O. nubilalis especially during August and September in Veneto and Friuli. Those wild records suggested control strategies by means of inundative releases of this parasite in the field using reared materials obtained from dr. J. Voegelé (France) and dr. S. Hassan (Germany). Mass releases of 50.000 and 150.000 parasites/ha in 1000m<sup>2</sup> plots were made (during 1983) 6-9 times in four localities (Veneto and Friuli), against the 1st and 2nd piralid flights. Results suffered for unusual climatic troubles. Maximum eggs masses parasitization of Ostrinia were variable (19%-79%).

Before harvest both Ostrinia larvae per plant and ears erosions were reduced in treated plots but not always in a sensible way. Increase in production (1000 kg/ha) was recorded only in one locality.

In order to get better practical results it seems necessary to improve the delivery and stocking systems of the Trichogramma employed.

**S19.1.** PRIMARY RESULTS ON THE UTILIZATION OF TRICHOGRAMMA EVANESCENS WESTW.  
**9** AGAINST THE ASIAN CORN BORER O. FURNACALIS Q. IN THE PHILIPPINES.

L. TRAN

S. A. HASSAN

PGCPP/BPI, MANILA/PHILIPPINES

BBA, DARMSTADT, W. GERMANY

Trials on the use of Trichogramma evanescens Westw. against the asian corn borer Ostrinia furnacalis Quenee in the Philippines were carried out at six locations throughout the country. The parasitism reached 40 to 76.9 % depending on the population of the insect pest existed in the area. Further trials are undertaken to improve the effectiveness of Trichogramma by determining the releasing time and dose.

**S19.1.** OPTIMIZING SEX ALLOCATION, CLUTCH SIZE AND FORAGING IN EGG PARASITIDS.  
**10**

J.K. WAAGE

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A history of mass rearing of Trichogramma reveals an empirical programme in which scientists have been content to know WHAT Trichogramma does, and not WHY it does it. I suggest that answers to these WHY questions hold the key to efficient production of Trichogramma for biological control. By judicious application of evolutionary models of optimal sex allocation, clutch size and foraging, the behaviour of Trichogramma in mass rearing systems and in the field can be better understood. This understanding opens several avenues for the manipulation and improvement of rearing systems for Trichogramma and other egg parasitoids.

**S19.1.**  
**11** TWO UNIDENTIFIED SPECIES THAT PARASITE HELIOTHIS EGG  
ON COTTON CROP.

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Two species of Trichogramma found in Heliothis eggs in cotton crop in the SW. of Spain are summarily described.

One of these species is thelitokous or arrhenotokous according to rearing temperature.

Release of mass reared individuals of both species in cotton plots resulted in a Heliothis population eight times less on "Trichogramma treated" plots than in those subjected to chemical control.

**S19.1.**  
**13** STUDY OF TRICHOGRAMMA SPECIES FROM BRASSICAE GROUP

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5 Bansko Shossé - SOFIA 1731 - BULGARIE

SUMMARY

In U.R.S.S. and BULGARIA one Trichogramma species used in biological control against many agronomic pests is wrongly named Trichogramma euproctidis GIRAULT 1911. This species correctly corresponds to the NAGARKATTI and NAGARA 1971 redescription of T. euproctidis, but these authors have not seen the types. There are PINTO and al. who were the first in 1978 to notice the identification error after having seen the types. Succeeding to this observation, VOEGELE has described in 1982 the species used in U.R.S.S. and BULGARIA under the name of T. pinto, but by classifying it in the euproctidis group near T. euproctidis and T. brassicae. After examining the T. ei we have seen that it belongs to the minutum group while T. pinto and T. brassicae belong to a particular morphological group synonymous of euproctidis NAGARKATTI and NAGARAJA group that have been named brassicae.  
(morphology of the)

We propose to compare the three mentioned species, then to give a particular interest to the two species of brassicae group. After the study of some crossing, we will try to separate the two similar species by studying their esterases in electrophoresis. We will also analyse the polymorphism of these enzymes and the differences between populations. We will, at last, make the point on the geographic repartition and the hosts of these species.



S19.1.  
14

Morphological Characterization of Trichogramma

B. Pintureau, J. Voegelé

Taking in account the variability of the male antennae in two species *T. semblidis* and *T. rhenana*, the profusion of new species and the necessity of a practical identification key for this genus, the authors propose some modifications at the classification given in the first international trichogramma symposium.

S19.1.  
15

ESTERASES PREIMAGINAL COLD DEVELOPMENT OF TRICHOGRAMMA  
NAGARKATTI VOEGELE and T. EVANESCENS WESTW.

L. OLIVEIRA,<sup>\*\*</sup> J. VOEGELE,<sup>\*</sup> B. PINTUREAU<sup>\*</sup> and L. ANNUNCIADA.<sup>\*\*</sup>

\* I.N.R.A. - Station de Zoologie - 37 boulevard du Cap 06 602 ANTIBES (France).

\*\*Universidade dos Açores - Laboratorio de Ecologia, 95 000 PONTA DELGADA Açores  
Portugal

Esterases studies on *Trichogramma* exposure to cold 20 days  
12°C and one month 3°C reveal specific enzymatic modification.

S19.1.  
16

SELECTION OF TRICHOGRAMMA MAIDIS PINTUREAU AND VOEGELE  
(HYM. TRICHOGRAMMATIDAE) FECONDITY

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FRANCE

The number of Ephestia kuehniella (Lep. pyralidae) eggs parasited during the first seven days by T. maidis presents a high heritability ( $h^2 = 0,45$  by the mother-daughter regression method) in the case of a mixture of 20 Trichogramma strains originated from many central european countries.

This fact permits to select (50 % pression) the character during 5 generations. Two methods were used, one called "by strains", the other "massal".

Selection was efficient, the fecondity increasing being 53 % with the "by strains" method and 71 % with the "massal" method.

In to compare the parasite efficacy of the selected strains with the no selected reference we have made releases part in green houses, part in fields in parcels infested by Ostrinia nubilalis (Lep. pyralidae).

At last, we have effected fecondity mesures on the selected populations after several generations, to control the stability of the character.

S19.1.  
17 HISTOCHEMICAL STUDY OF THE METABOLISM OF TRICHOGRAMMA MAIDIS DURING  
ITS DEVELOPMENT IN THE HOST EGG

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Station de Zoologie - C.N.R.A. - Route de St Cyr 78000 VERSAILLES France

The glycogen and proteinaceous reserves of Trichogramma maidis (Hym. Trichogrammatidae) are studied during its development in the laboratory host, Anagasta kuehniella Zell. (Lep. pyralidae).

The apparition and evolution of these substances are followed from hatching to the last instar larva in the adipose tissue.

S19.1.  
18

THE STATUS OF TRICHOGRAMMA SYSTEMATICS IN NORTH AMERICA

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92521

The Trichogramma fauna of North America is reviewed and briefly compared to that of other parts of the world. The reliability of various morphological characters in species discrimination also is discussed.

S19.1. FURTHER CONTRIBUTION TO THE KNOWLEDGE OF THE MALE GENITALIA  
19 IN THE TRICHOGRAMMATIDAE (HYM. CHALCIDOIDEA)

G. VIGGIANI

Institute of Agricultural Entomology, University of Naples-PORTICI

After the first comprehensive research on the structure and the significance of the male genitalia in the Trichogrammatidae (Viggi ani, 1971) further data have been accumulated on several new genera and species, especially on Oligosita Walk. and Trichogramma Westw.

The present knowledge is reviewed taking into account general and specific aspects of taxonomic and phylogenetic value.

519.1. 20 PARASITE AND HOST DENSITIES RELATIONS BETWEEN TRICHOGRAMMA  
MAIDIS PINTUREAU-VOEGELE AND OSTRINIA NUBILALIS HUBN..

I. BADENHAUSSER, J. VOEGELE, Y. MIERMONT and J. PIZZOL

I.N.R.A. - Station de Zoologie - 37 boulevard du Cap 06 602 ANTIBES(France)

In the case of a close and open environment on laboratory and field scale, we assist with different host parasite densities to normal parasitism or to super-parasitism in the former situation, to different level of dispersion in the second.

519.1. 21 BIOLOGICAL AND ECOLOGICAL COMPARISON OF TRICHOGRAMMA AND TELENOMUS AS  
CONTROL AGENTS OF LEPIDOPTEROUS PESTS

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Trichogramma and Telenomus are major egg parasitoids of Lepidoptera, sharing the same host resources with each other in different ecosystems. They are often important control agents of various lepidopterous pests. To evaluate their potential as control agents from the viewpoint of life history strategies of parasitoids, some biological and ecological characteristics, such as host specificity, adult longevity, fecundity, sex ratio, pattern of ovigenesis, length of development time, capacity of population increase, host-searching ability, response to host density, and competitive ability are compared between Trichogramma and Telenomus in the egg parasitoid complexes of some lepidopterous pests. A discussion of these characteristics and their interrelationships is presented concerning a role of Trichogramma and Telenomus in controlling lepidopterous pests.

S19.1.  
22

BIOLOGICAL STUDIES OF TRICHOGRAMMATOIDEA  
BACTRAE FUMATA NAGARAJA IN THE LABORATORY

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The developmental history, longevity, fecundity, mortality of immature stages, sex ratio per parasitized egg, rate of parasitism of Trichogrammatoidea bactrae fumata Nagaraja on Corcyra cephalonica Stn. were made in laboratory condition. The duration of the progeny produced by mated and virgin female under fed or starved condition was ranging from 8 - 9 days. The overall mortality of immature stages of mated and virgin female was 9.08, 6.71, 3.61 and 2.61 % under fed and starved condition respectively. The virgin female produced all male offspring. However, fed or starved of mated female parasitoid produced either female, male or both sexes. The mean total number of C. cephalonica eggs parasitized by mated and virgin of fed parasitoid was 48.96 & 48.68. The total mean number of offspring produced by a mated and virgin female was 67.36 and 102.47 under feeding condition and 10.20 and 9.88 under starvation. The longevity of fed female was significant longer than fed male.

S19.1.  
23 FIRST RESULTS IN QUANTIFYING NATURAL PARASITISM ON  
HELIOTHIS ARMIGERA IN TOMATO FIELDS IN SOUTH PORTUGAL

Jorge ARAÚJO, Carola MEIERROSE  
University of EVORA, Portugal

Summary

Field observations on natural parasitism on Heliothis armigera eggs by Trichogramma rhenana have been undertaken during eight weeks in 1982, on a semi-industrial tomato field near Evora, S-Portugal. The field observations have been effected from the transplantation of the seedlings on until the first pesticide application.

The average parasitisation rate from mid-June to mid-August was 80,4%. The average value of parasites per egg was 1,9 with a sex ratio ♀ : ♂ of about 2:1.

519.1. SEMIOCHEMICALS INFLUENCING BEHAVIOR OF EGG PARASITIDS: CONSIDERATIONS  
25 FOR BIOLOGICAL CONTROL

W. JOE LEWIS<sup>1</sup> and DONALD A. NORDLUND<sup>2</sup>

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Semiochemicals emanating from the crop, associated plants, and host insects have been shown to be of major importance in the foraging activities of Trichogramma, Telenomus, and Chelonus species.

The interrelations of parasitoid behavior and these semiochemicals will be analyzed and discussed in connection with design of biological control programs.

519.1.  
27 THE HOST EXAMINATION BEHAVIOR OF FEMALE TRICHOGRAMMA MINUTUM RILEY

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The female parasitic wasp Trichogramma minutum typically examines a potential host by walking repeatedly over the surface and drumming her antennae against it. This behavior not only allows the wasp to detect putative chemical signals, but also to assess form and size. Form and size are important cues in host selection since they mediate acceptance or rejection of the potential host object. Analysis of filmed behavior sequences and the paths taken during host examination has provided information about the role of surface discontinuities and convexity in host selection. Possible mechanisms by which these parameters are determined will be described. Host examination appears to affect subsequent behavior of the parasite; the role of this phenomenon in host preference will also be discussed.

**S19.1.** BEHAVIORAL VARIATIONS BETWEEN TRICHOGRAMMA SPP. STRAINS, A TECHNIQUE  
**28** FOR CANDIDATE-STRAIN EVALUATION.

G.A. PAK AND J.C. VAN LENTEREN

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Binnenhaven 7, 6709 PD Wageningen, Netherlands

Cabbage crops in the Netherlands are attacked by a lepidopterous pest complex, of which Mamestra brassicae, Pieris brassicae and P. rapae are the major species. A research program has been set up to assess the possibility to control these pests by inundative releases of Trichogramma. Characteristics of the host search behavior are assumed to be the determinant factors for species- or strain - efficiency. A worldwide collection of different Trichogramma species, and different strains of each species, was obtained.

Laboratory experiments are conducted to determine behavioral variations among strains. Characteristics identified as evaluation criteria are activity at low temperature, host suitability, host-age and host-species selection, reaction to kairomones associated with the crop and the host species, and influence of kairomone and host egg distribution patterns. Interstrain variations for these characteristics were found. The control capabilities of promising candidate strains are tested in field experiments.

**S19.1.** INTRODUCTION TO THE WORK COORDINATED BY THE SUBGROUP "ECOLOGY AND  
**29** BEHAVIOUR OF TRICHOGRAMMA"

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The need of ecological and ethological studies for the preselection of natural enemies, the development of mass production, introductions and quality control methods is expressed by most students of biological control. Opinions are, however, quite different with respect to the amount of basic research necessary for preselection and application of beneficial insects. In this subgroup we hope to contribute to a further increase in use of Trichogramma through a search for efficient evaluation and quality control methods. The main aims of the group will be:

1. A careful selection of ethological and ecological methods to be used for preselections of strain and/or species of Trichogramma under different climatological conditions and against different pests.
2. Development of ideas on fitness characteristics to be used in the development of mass rearing techniques, in which the highest number of fit, mated females per unit of host biomass can be produced; the same with respect to quality control.
3. Search for possibilities to increase parasitism in the field, for example by applying kairomones to the crop.

519.2.  
1

## THE CONTEXT OF BIOLOGICAL CONTROL RESEARCH IN AUSTRALIA

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This paper is intended to provide background information about biological control research in Australia. It deals with the legislation controlling the import and release of biological control agents; the organizations responsible for relevant research; channels for coordination of research; facilities available in Australia and overseas; current collaborative programs with other countries; and briefly highlights some successful programs of current interest, and new programs presently being developed.

519.2.  
3

## CANADIAN INTERESTS IN THE INTERNATIONAL ASPECTS OF BIO-CONTROL.

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Canada has been importing bio-control agents since 1882, with Europe the source of most of the introduced agents. Since the 1930's, the Delemont Station of the CIBC has been the centre for the international aspects of the program. In general, Canadian research projects on the control of target pests have contracted with the CIBC for studies of the pest and potential bio-control agents in their native countries, followed by the introduction of selected agents. Canadian programs, particularly those in the biological control of weeds, are closely coordinated with those in the USA. These approaches have been successful but additional mechanisms may be needed to extend the search for bio-control agents to other countries with temperate climates. An international organization that provided current information on bio-control programs, and an effective means of access to services and facilities could be useful. Access to information on current research programs on pest species in other countries could provide useful contacts for the initiation of searches for bio-control agents. In addition, there is a need for the compilation of an international data base to record bio-control information so that future programs can build on past experience.



S19.2.  
4

THE COMMONWEALTH INSTITUTE OF BIOLOGICAL CONTROL AND ITS  
INTERNATIONAL PROGRAMME

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Silwood Park, Ascot, Berkshire SL5 7PY

The CIBC is a component of the Commonwealth Agricultural Bureaux, an international agency owned by Commonwealth Member countries which contribute to its core budget. The CIBC has provided services for countries undertaking biocontrol programmes since 1927; principally to advise, procure natural enemies and disseminate information. From the outset, its programme was international with projects undertaken for all who wished to use the service. The CIBC now operates world-wide from biocontrol stations in India, Kenya, Pakistan, Switzerland and Trinidad, managed from a centre at Imperial College, Silwood Park, U.K.

To broaden the scope of its service, it is developing links with other institutes with special expertise or similar objectives. In this way, it hopes to develop a consortium approach to the mounting of pest management programmes and therefore welcomes moves towards the development of an international biocontrol network.

P19.-  
1

SELECTING COTESIA (APANTELES) MELANOSCELUS TO ATTACK  
LARGE GYPSY MOTH LARVAE

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Cotesia melanoselus does not parasitize a high proportion of gypsy moth (Lymantria dipar) larvae in forests because females usually cannot successfully attack 4th stage and larger hosts. This presentation describes a program to genetically select a strain of the parasite which will successfully attack large hosts. By rearing the parasite continuously on 4th instars, it was found that parasites attacked 4th stage hosts more successfully each generation. Comparisons of the behavior of a non-selection strain with the 11th generation of the selection strain showed that differences in behavioral preferences occurred, with the selection strain preferring to attack larger hosts than did the non-selection strain. This shows that host preferences can be changed by a program of genetic selection, and could eventually lead to the development of a more effective parasite.

**P19.-**  
**2** BIOLOGICAL CONTROL OF LEAFMINERS (DIPTERA; AGROMYZIDAE) ON GREENHOUSE TOMATOES IN THE NETHERLANDS.

O.P.J.M. MINKENBERG and J.C. van LENTEREN.

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Since 1976 the tomato leafminer, *Liriomyza bryoniae*, caused serious problems in Dutch greenhouses. Pesticides against this leafminer disrupted the succesful biological control by *Encarsia formosa* of the other main pest, the whitefly *Trialeurodes vaporariorum*. Therefore a biological control program against the tomato leafminer was developed with the Braconid *Opius pallipes*. This method was tested in commercial greenhouses. A second leafminer, *L. trifolii*, was introduced in 1976 from the U.S.A. and caused problems in vegetables since 1980. Biological control by *O. pallipes* is not effective against this species as its eggs are encapsulated by *L. trifolii* larvae.

Last year we obtained two new parasites, the Eulophid *Diglyphus isaea* and *Chrysocharis parksi*. Eggs of these two parasites are not encapsulated by *L. trifolii* larvae. In order to obtain information about their control capacity and to develop mass-rearing and introduction methods we started to study their life history and behaviour.

**P19.-**  
**3** THE FEEDING ACTIVITY OF Chrysoperla carnea (STEPHENS) TOWARDS Barathra brassicae L. AND Spodoptera littoralis (BOISD.)

CETIN SENGONCA & ALFONS GROOTERHORST

Institut für Pflanzenkrankheiten der Universität Bonn, W.Germany

In the laboratory studies on the feeding activity of Chrysoperla carnea towards Barathra brassicae and Spodoptera littoralis were conducted. The daily number of lepidopterous eggs consumed by all larval stages of C. carnea was determined. Thereby a strong relationship between the number and weight of the eggs consumed became apparent. Furtheron the activity of the predator towards the larvae of both lepidopterous species was observed.



Section 20	Integrated Control .....
R 20.1.	<i>Present Status of Integrated Pest Management Programs .....</i>
R 20.2.	<i>Strategies for the Integrated Control of Pests of Man and Animals .....</i>
R 20.3.	<i>Problems and Prospects of Integrated Plant Protection against Major Arthropod Pests .....</i>
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R 20.6.	<i>Biotechnical Methods as Part of Integrated Control Systems .....</i>
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S 20.2.	<i>Incorporation of Biological Control in Integrated Pest Management Programs: Natural Enemies and Pesticides .....</i>
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**R20.1.** NEW STRATEGIES AND TACTICS TO INTEGRATE BIOLOGICAL CONTROL  
**1** WITH CHEMICAL CONTROL IN IPM PROGRAMS

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Kusano 540, Kusano-machi, Kurume City, Kyushu 839-11, JAPAN.

1. Development of selective pesticides

Commercial enterprizes ordinarily are not interested in developing selective pesticides, which have been recommended for use in IPM programs (IPM-p). The beneficial dimensions of IPM-p to the enterprizes should therefore be discussed with them, and their approval should be obtained.

2. Utilization of non-selective pesticides

Non-selective pesticides must be used in current IPM-p. To diminish their destructive effects, new tactics should be applied to determine the necessity and timing of treatments. These should include methods to predict insect occurrence with pheromones, kairomones, other trapping techniques, systems analysis and simulation models.

3. The use of pesticide-resistant predators should be increased.

4. The practice of manipulation, conservation and augmentation of natural enemies should be enhanced.

**R20.1.** A STATE AGRICULTURAL EXTENSION PEST MANAGEMENT PROGRAM:  
**2** FROM DEVELOPMENT TO FULL IMPLEMENTATION

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The first Federally funded extension integrated pest management (IPM) programs were initiated in 1971 on tobacco in N. Carolina and cotton in Arizona. In 1972, a program on alfalfa was started in Indiana. Since that time the major field crops in Indiana including corn, soybeans and small grains have been added. Early program activity included weekly field scouting by extension personnel, development and distribution of scouting reports for each field scouted and individualized pest management (PM) recommendations. In the early phase of the program, producers paid a nominal fee for scouting services. As the program developed, producers became more willing to provide total support for program activities. Based on this grower support, it was decided that these programs could flourish on their own and plans were formulated to move them to the private sector.

In 1976, the first private business offering PM services was started. Since that time 16 companies have been established in the State. With the changing role of extension in relation to these programs has come the establishment of an extension support group for these private programs, as well as PM in general. Activities of this support group include, in addition to counsel in program establishment, the development and/or refinement of scouting techniques, thresholds, management alternatives, scouting and decision-making manuals, schools for training scouts and others interested in IPM, pest prediction techniques, advisories, etc.

## **R20.1.** PROGRESS IN DEVELOPING IPM IN MALAYSIAN PLANTATION CROPS **3**

B.J. WOOD

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IPM is easiest to implement on large plantations, and has been widely encouraged in Malaysia in the last two or three decades. The experiences have contributed to the general principles of the approach. Four aspects are considered - (i) understanding the agroecosystem, (ii) knowledge of pest status, (iii) developing means for the most effective least frequent control intervention, and (iv) further research needs.

The agroecosystem is characterised by lack of marked seasons. The climate continuously favours pest increase but also good natural balance, especially in perennial crops. Key pests are few, but serious. Upsurge of occasional or potential pests is a strong risk, as a side effect of control measures. Monitoring is crucial to decision-making.

Appropriate strategies include environmental suppression, resistant cultivars, mass release, pheromones, and biological insecticides. With chemicals, selectivity is important, but a good pest kill helps restore disrupted natural balance.

## **R20.1.** HARMONIZING USE OF PESTICIDES IN A PEST MANAGEMENT PROGRAM IN NOVA SCOTIA APPLE ORCHARDS **4**

J. M. HARDMAN AND K. H. SANFORD

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Our objective is to use insecticides and miticides in such a way that apple yield and quality meet high standards and two of the major pitfalls of pesticide use - pest resistance and harm to non-target species - are avoided. Tactics to avoid or delay the onset of resistance include alternating the use of different classes of pesticide already in current use and delaying as long as possible the use of newly registered chemicals particularly of a different class. Methods used to reduce harm to non-target species also tend to reduce the resistance problem. These tactics include using pesticides only when necessary as indicated by monitoring data and knowledge of economic thresholds; use of selective pesticides; use of low dosages of pesticides; and careful timing of pesticide applications to have greatest effectiveness in reducing pest damage and/or preserving natural enemies. In addition careful timing and selection of the appropriate chemical can permit simultaneous control of several above-threshold species.

**R20.1.** PRESENT STATUS OF THE COTTON INTEGRATED PEST MANAGEMENT IN THE STATE OF  
**5** SÃO PAULO, BRASIL.

S. GRAVENA<sup>1</sup>

<sup>1</sup>Deptº de Defesa Fitossanitária, FCAV-UNESP, 14870-Jaboticabal, SP, Brasil

The selectivity of insecticide and the natural enemy population dynamics were intensively studied in cotton agroecosystems in order to implement the IPM in the State of São Paulo conditions. The integrated and supervised strategies of pest control were compared to the conventional strategy adopted by the growers in several field experiments since 1979. The IPM was also taken directly to the field in an extension basis and in cooperation with the State Agricultural Extension Service through short IPM courses and orientation. By the experimentation, the number of applications was reduced from 10-15 to 4-6 per season in average and by the extension service the number was reduced to 2-3 per season with the yield varying from 2200 to 3000 kg/ha but never less than the conventional strategy, in 1982/1983. *Bacillus thuringiensis* Berliner and BT + methomyl or amitraz and *Heliothis* spp. at the action level of 10 larvae/100 plants were the tactics used. During the studies it was found that *Heliothis* spp. changed its status from key to secondary pest and the cotton leafworm *Alabama argillacea* (Huebner) became the key pest for IPM. The action and inaction levels for *A. argillacea* were determined to be 3 larvae/plant and 1 predator/larvae, respectively. It was registered an epizootic of the fungus *Nomurea rileyi* (Farlow) infecting *A. argillacea* in a cotton field, in 1981, reaching 87,8% of infected larvae. Finally, the incidental introduction of the boll weevil *Anthonomus grandis* (Boheman) is expected to bring changes in some extension to the present status of the cotton IPM strategies in São Paulo.

**R20.2.** INTEGRATED MANAGEMENT OF LIVESTOCK PESTS IN TEXAS, U.S.A.  
**1**

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A variety of control measures are being employed to minimize economic losses from serious livestock insects and arthropod pests of Texas farm animals. Management strategies have been developed by all applicable subject matter departments represented in an agricultural university system. Insect management techniques employed include sterile male releases for screwworm, animal attachment devices for biting flies and ticks, IGR chemicals for house fly and pyrethroid sprays and selected baits for premise pests. The Mexican-American Screwworm Eradication Program has totally eliminated the screwworm from Texas since September 1982. Management strategies are being developed for difficult to control horse flies which includes the wick application of repellent and pyrethroid materials in both ear and tail attachments to animals. Statewide distribution data has been developed for the cattle grub to implement a 4-year Extension educational program to eliminate economic losses in Texas. The integration of new technologies is enhancing profits for the vast livestock production systems which contribute approximately 60% of the State's agricultural income.

**R20.2.** DEVELOPMENTS IN THE INTEGRATED CONTROL OF MALARIA  
**2** VECTORS IN INDIA

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Interruption of malaria transmission mainly depends on vector control. In India Anopheles culicifacies is the most important transmitter of malaria in rural areas, and A. stephensi in the urban areas. Control of these vectors is beset with many problems, foremost being the development of insecticide resistance. With reference to this, experiments have been done to demonstrate the usefulness of improved coverage in extending the useful life of DDT in otherwise resistant areas. Besides a long term strategy is being worked out to test the value of integrating the old and forgotten methods of vector control viz., source reduction, environmental improvement, personal protection, community participation and the biological control. Results of these developments would be discussed as a practical means of malaria control in India.

**R20.2.** INTEGRATED CONTROL OF SIMULIUM CHUTTERI IN SOUTH AFRICA  
**3**

M.CAR, F.C.DE MOOR

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Simulium chutteri is a pest species of veterinary importance in South Africa mainly along the Orange-, Vaal- and Great Fish River. During the last years three methods were used for its control: 1. By closing the sluice gates of the Vaalharts Weir in the Vaal River and of the P.K.Le Roux Dam in the Orange River for at least 12 weekends a year, the water-level is manipulated. This results in a dislocation of large blackfly larvae, which cannot resettle and die. 2. Where water-level manipulation is not effective the biological larvicide TEKNAR containing Bacillus thuringiensis Berliner var. israelensis de Barjac has been tested successfully. A concentration of 1,6 ppm of the larvicide resulted in a significant ( $p < 0,05$ ) decrease of S. chutteri larvae in the Orange River at a flow rate of 38 m<sup>3</sup>/sec 11 km below the treatment point. Non-target organisms except some chironomid larvae were not affected. Adult Simuliidae can be repelled and controlled by dipping live-stock with pyrethroids. Animals have to be treated weekly to obtain a high level of protection.



**R20.2.** THE USE OF *BACILLUS THURINGIENSIS ISRAELENsis* PREPARATIONS  
**4** IN AN INTEGRATED MOSQUITO CONTROL PROGRAM IN WEST GERMANY

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(Mosquito Control Association in West Germany)

An "integrated mosquito control program" comprising microbiological and biological methods, an organic surface film and environmental management is organized by an association of more than fifty towns and communities in the Upper Rhine Valley to control larvae and pupae of mosquitoes. Since 1981 *Bacillus thuringiensis israelensis* (BTI) is used in our program to control abundant mosquito species like *Aedes vexans*, *Ae. sticticus*, *Ae. rossicus*, *Ae. cantans*, *Ae. communis*, *Ae. punctor* and *Culex pipiens*. In 1983 about 3300 ha were successfully treated with BTI. Several BTI granulates were tested and 21 000 kg of a BTI-sand granulate were applied to 1 200 ha with helicopters. BTI offers us high efficacy against mosquitoes, low costs for treatment, enough time for control when larval instars occur and nearly total safety for all other organisms.

**R20.3.** PEST ABUNDANCE, PESTICIDE USAGE AND LEVELS OF FRUIT DAMAGE IN A PEST  
**1** MANAGEMENT PROGRAM IN NOVA SCOTIA APPLE ORCHARDS

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The number of orchards in this survey varied from 132 in 1980 to 163 in 1982. Those pests with counts most often above their economic threshold included the winter moth (86% of the orchards), the European red mite (67%), the apple maggot (49%), the eye-spotted bud moth (46%) and the codling moth (40%). The mean number of insecticide applications ranged from 2.80 per orchard in 1980 to 2.45 per orchard in 1982 while the means for miticides varied from 0.39 in 1980 to 0.60 in 1982. The winter moth was the most frequent primary target of insecticide applications (368 over all orchards in 3 years), followed by the codling moth (258), the European red mite (229), and the apple maggot (206). The mean cost of insecticide applications was \$42/ha (92 DM/ha) while the cost of miticides was \$25/ha (54 DM/ha). Insect injury to apples varied from 3.6% in 1980 to 1.76% in 1981 and 1.95% in 1982. The most damaging species were the codling moth (0.56% fruit injury), the rosy apple aphid (0.56%), fruit-chewing caterpillars - primarily the winter moth (0.54%) and mirids (0.29%).

**R20.3. GEOGRAPHICAL DISTRIBUTION OF PANDEMIS HEPARANA AND  
2 ADOXOPHYES ORANA IN THE FEDERAL REPUBLIC OF GERMANY**

E. DICKLER

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6901 Dossenheim, Federal Republic of Germany

In field trials carried out over 10 years at Dossenheim Germany with a selective granulosis virus against codling moth a severe fruit loss by leafrollers was found. The leafroller damage was mainly due to the species *Pandemis heparana* and *Adoxophyes orana*. Thus, in 1981 and 1982 the geographical distribution of the two tortricids was observed at 55 locations in the Federal Republic of Germany using pheromone traps. *P. heparana* was captured at all study sites, whereas *A. orana* did not occur at 3 locations. The peak flight of the spring moth of *P. heparana* was generally found to be 3-4 weeks later than that of *A. orana*.

**R20.3. APPLYING INTEGRATED PEST MANAGEMENT ON COTTON IN THE  
3 PHILIPPINES**

HASSE, V., DREWS, A., CORALES, R., AND WEHREND, O.

all: Philippine-German Cotton Project, Alacan, San Fabian,  
Pangasinan, Philippines

Out of 12 major arthropod pests of cotton in the Philippines three were identified as key pests.

Damage caused by the leafhopper *Amrasca biguttula* (Shir.) is reduced to non-critical levels with the introduction of a tolerant variety. The flower weevil *Amorphaidea lata* Motsch. attacking only open flowers, will not reach pest status if the crucial fruit-setting period is shortened to at most three weeks using higher planting densities. Chemical control can be delayed at the beginning of an infestation of the boll worm *Heliothis armigera* (Hb.) by application of *Bacillus thuringiensis* Berl., and substituted in part by the introduction of a village based mass-rearing and release of *Trichogramma australicum* Girault.

The need for chemical control measures is determined by field scouts using a surveillance system which includes critical pest threshold levels. The pesticide recommendations take into consideration the plant age, the target pest, and the possible occurrence of insect resistance and resurgence.

The system also monitors crop development in relation to a preset minimum yield target.

**R20.3.** 4 TIMELY INSECTICIDE APPLICATION TO CONTROL THE BROWNPLANTHOPPER,  
NILAPARVATA LUGENS STAL AND ITS EFFECT TO THE PREDATORS.

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Dichlorvos, methomyl, phenthoate. cyanofenphos, fenitrothion, deltamethrin, pyrdaphenthion, fenitrothion + bpmc, diazinon + bpmc were evaluated for its efficacy against the brownplanthopper. The insecticides were applied based on the population density of 10 hoppers per hill at 2 - 4 weeks after transplanting (wat), 25 hoppers at 5 - 9 wat, 50 hoppers at primordia stage and 75 hoppers at ear-bearing stage. Due to the different mode of action the frequency and total spraying applied varies between the insecticides, ranging from 2 to 5 times. The most effective was combination of fenitrothion and bpmc. Some insecticides caused population build up of brownplanthoppers. Predators present before the spraying were coccinellid, Coccinella arcuata, myrid bug, Cyrtorhinus lividipennis, staphylinid weevil, Paederus tamulus, carabid beetle, Casnodea interstitialis and the spider. Predator count after the last application indicated little toxic effect of fenitrothion + bpmc to the spiders and C. lividipennis, while no adverse effect was observed to P. tamulus, C. interstitialis and C. arcuata.

**R20.4.** 1 NATURAL ENEMIES IN INTEGRATED CONTROL SYSTEM OF CITRUS  
PESTS IN USSR

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Coccids (18 species), citrus whitefly-Dialeurodes citri Aschm., mites-Panonychus citri Mc.Greg., Phyllocoptruta oleivorus Asmh., green aphid-Aphis spiraecola Patch. are the main citrus pests on the Black Sea Coast of Georgia. Recently we have the effective complex of natural enemies (more than 50 species) which has been formed by introduction and acclimatization of some biological agents, by ecesis and migration of indigenous parasites and predators on citrus pests.

The integrated system, permitting to use the effective action of natural enemies with the application of pesticides against key species has been worked out. It includes 3-4 sprays of mineral oil with the combination of fungicides and the differential using of phosphororganic pesticides against key pests, if their number level increases to economic threshold.

**R20.4.** The natural enemies of pests on apple trees at the  
**2** some orchard in Croatia

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41000 Zagreb Mažuranićev trg 6 Yugoslavia

The paper show the results of the determination of natural enemies on apple trees at the grand orchards in Croatia - Yugoslavia.

The dynamics and varieties of predators and parasites mentioned in this paper were found and determined at the time of monitoring of the orchard to undertake integrated control measure.

The results of following entomofauna special predators and parasites refer to years 1980, 1981, 1982 and 1983

**R20.4.** DATA ON AN INTEGRATED CONTROL PROGRAM ON APPLE ORCHARDS IN GREECE  
**3**

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The most important pests of apple trees in Greece are the scales, mainly Quadraspidiotus perniciosus and Parlatoria oleae and the codling moth Laspeyresia pomonella. In an attempt to apply an integrated control program in the apple orchards, the biological control agents have been studied the last years. Thus the introduction and establishment of the parasite Prospaltella perniciosi against Quadraspidiotus perniciosus gave good results. The native parasites and predators of P.oleae, have been studied. Also the natural enemies of L. pomonella have been surveyed. Thus three parasites were found parasitising the codling moth in Greece. Of these parasites Pristomerus vulnerator (Panz) is considered the most important and widely distributed.

Second in abundance are the Ascogaster quadridentata (Wesm.) and Ephialtes caudatus (Ratz.). The larval endoparasite Pristomerus vulnerator is distributed all around apple orchards in Greece and parasitism in unsprayed orchards reached 15% and in sprayed ones 3,5%.

**R20.4.** APPROACH TO AN INTEGRATED CONTROL OF THE TORTRICID  
**4** ADOXOPHYES RETICULANA IN APPLE ORCHARDS

PETER GALLI

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In the South-West of Germany the tortricid Adoxophyes reticulana has become one of the most important pests in apple orchards. Because of the larvae's hidden way of living 3 or 4 treatments with insecticides are necessary, yet not always effective, even if applied at the hatching time. Moreover, the pesticides used are more or less harmful to the beneficial insects and thus considered unsuitable for an integrated control program insisting on the incorporation of biological limiting factors. Investigations during the last 3 years in apple orchards indicate that natural enemies of this tortricid, if not reduced by chemicals, may be found in greater number than expected, especially parasitic hymenoptera and diptera (parasitization up to 40 %). We therefore tested the IGR Fenoxycarb (Ro 13-5223) which, while sufficiently suppressing the noxious tortricid, seems to be harmless to the parasites. According to our results this insecticide opens a new approach to an integrated control of Adoxophyes reticulana, utilizing the potential of natural enemies.

**R20.4.** RESULTS ON SOME ANTAGONISTS OF THE FRUIT LEAFROLLER  
**5** PANDEMIS HEPARANA DEN. ET SCHIFF. (LEP.; TORTR.)

W. HASSELBACH AND E. DICKLER

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A report is given on parasites of *Pandemis heparana*, an important pest on apple trees. These parasites belong to the Hymenopteran families Ichneumonidae, Braconidae and Chalcididae. They were found in Dossenheim, Federal Republic of Germany, in 1981 to 1983. Also a mite preying on eggs, so far not known from Lepidoptera eggs, is being described.

Possibilities for an effective control of this leafroller with these antagonists are discussed.

**R20.4.** THE INTEGRATED CONTROL OF APPLE APHIDS -  
**6** THE ROLE OF ALDER WINDBREAKS

ALAN GANGE

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A comprehensive survey of apple aphid predators identified insects moving from Alder windbreaks as an important component of an integrated pest control programme. Black-kneed capsids and anthocorids develop on alder feeding primarily on the aphid Pterocallis alni. When the predatory insects are adult the aphid population is declining and the adults move to the nearby apple trees where they feed on pest species. This paper examines the biology and ecology of P. alni in order that the predator populations may be manipulated, be reliable and appear at the correct time to control orchard pests.

Populations increase rapidly to a peak, then suddenly decline. A high initial population results in a peak in early June, whereas a low initial population gives a peak in late July. The sudden decline is caused by migration of alate aphids which disperse to colonize other alder. Pruning of the windbreak at different times in summer and winter has a marked effect on aphid populations and consequently the predators. A simulation model of integrated pest control in orchards is being developed and tested

**R20.4.** GENETIC IMPROVEMENT OF AN AUSTRALIAN STRAIN OF THE MITE  
**7** PREDATOR *TYPHLODROMUS OCCIDENTALIS* NESBITT.

GERRIT VAN DE KLASHORST

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A strain of *T. occidentalis* (Acari:Phytoseiidae) was selected for resistance to synthetic pyrethroids (SPs) with the short residual compound bioresmethrin. Development of resistance and its inheritance are discussed. Slide-dip testing showed cross-resistance to fenvalerate and permethrin, while organophosphate resistance was maintained. Performance of the selected strain was tested in 'mini-orchards' in a glasshouse. The strain was found tolerant to applications of the SP bioresmethrin applied in that system.

**R20.4.** STUDIES ON PESTICIDE RESISTANCE IN THE PHYTOSEIID MITE,  
**8** AMBLYSEIUS LONGISPINOSUS (EVANS)

LO, P. K. C., WU, T. K. AND TSENG, S. K.

TARI, Wu-feng, Taichung, Taiwan, ROC.

The phytoseiid mite, Amblyseius longispinosus is the most important predator of spider mites in strawberry, mulberry, beans, citrus, pear and many flower crops in Taiwan. 17 acaricides and 6 insecticides were used to select the predators which were collected from different locations and plants. We have selected this predator for resistances to carbamates, organophosphates and pyrethroids in the laboratory and obtained dimethoate, dimethoate-carbaryl and carbaryl resistant strains. the genetics of these resistances are discussed.

**R20.5.** POSSIBILITIES OF INTEGRATED PLANT PROTECTION AGAINST PESTS OF  
**1** CEREALS IN THE G.D.R.

WETZEL, THEO Martin-Luther-Universität Halle-Wittenberg, DDR 4020 Halle/  
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In recent years considerable advances have been achieved in realization of an integrated plant protection against damaging insects of cereals. Especial emphasis is put on the control of pests of cereal-seedlings (e.g. *Delia coarctata*, *Oscinella frit*, *Zabrus tenebrioides*) and of insects damaging at the inflorescences (e.g. *Macrosiphum avenae*, *Contarinia tritici*, *Haplothrips aculatus*, *Oscinella frit*).

In addition to the consideration of tillage and cultivation measures, the introduction of a modern system of monitoring, the regard of economic thresholds and the saving strategies of useful insects. The simulation model of cereal leaf beetles and English grain aphid is presented. Basis for the elaboration of the integrated plant protection in cereals were numerous field trials and model trials. They were necessary for the elucidation of the population dynamics of pests and useful insects as well as the infestation-damage-relation.

**R20.5.** Possible interactions between phytophagous and predatory insects and the use of insecticides in cereal fields in Middle Europe

2

Th. Basedow

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The larvae of the wheat blossom midges, *Contarinia tritici* (Kirby) and *Sitodiplosis mosellana* (Géhin), after having damaged the wheat kernels, are preyed upon by epigeal predators. In this case the predators do not have a great economic significance, as was shown by key factors analysis of the midges population dynamics.

The cereal aphids, *Sitobion avenae* F., *Metopolophium dirhodum* (Walk.) and *Rhopalosiphum padi* (L.) are preyed upon by the epigeal predators before having reached economically critical numbers; i.e. the polyphagous predators, especially Carabidae, are of economic importance in this case. Stenophagous predators, such as *Coccinella septempunctata* L., have a delayed effect on cereal aphid populations, i.e. they do have an economic value, but not immediate one.

The use of broad spectrum insecticides against gall midge or cereal aphids results in a decrease of pests and predators as well. A widespread use of such insecticides may therefore enhance the danger of cereal aphids outbreaks and make necessary routine applications of insecticides. In a six year research programme this hypothesis is tested.

Possible ways of avoiding insecticide-induced outbreaks of pests are shown: the use of selective preparations and the application of economic thresholds, to avoid routine sprayings.

**R20.5.**

3

A MANAGEMENT SYSTEM FOR GRASSHOPPER POPULATIONS ON CEREALS

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A management system is being developed to provide grain growers of Saskatchewan with current information on grasshopper populations, crop development and growth, potential for crop damage due to grasshoppers and strategies for crop protection. The major aim is to minimize use of chemicals as a crop protection measure for maximization of crop yields.

There are three major components in the management system, namely, grasshopper dynamics, crop development and growth and crop protection optimization. Weather is the governor or the driving force for all the three components. Separate modules are being developed for each of the three components and tested on completion.

Crop damage by grasshoppers is closely related to the state of growth and the response of host plants when grasshoppers are feeding. Therefore, the temporal synchrony between incidence of grasshopper populations and production of leaf biomass in cereal crops in relation to weather conditions is the determinant of the effect of defoliation on crop yields.



## **R20.5.** PREDATORS AS AN AID TO THE CONTROL OF CEREAL APHIDS

**4**

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More than 350 species of predators were found in UK cereals. Gut dissection and serological techniques showed that many were feeding on aphids. Laboratory and field studies of consumption rate coupled with field experiments and farm surveys showed that predators and other natural enemies prevented aphid outbreaks in some years. These predators also feed on other pests in cereals and are a vital part of integrated pest management. Methods to increase their numbers and effectiveness in crops are currently being sought.

## **R20.5.** THE BASIS OF WHEAT CULTIVAR RESISTANCE TO APHIDS

**5**

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Histological examination of the salivary stylet sheaths produced by aphids feeding on wheat enables their path to be followed. The majority of tracks are branched, with most ending in the mesophyll or phloem. Most probes originated from the leaf epidermis above a vascular bundle. Penetration of the leaf tissue is entirely intercellular until the stylets enter a vascular bundle, when it becomes predominantly intracellular.

The proportion of salivary sheaths reaching the phloem and the pattern of branching was compared for aphids probing on Triticum monococcum and several cultivars of T.aestivum. The results are examined in relation to resistance of wheat to aphids, as assessed by measurements of aphid growth and fecundity.

## **R20.5.** INTEGRATED PEST CONTROL AND APPROACHES TO SOLVING THEORETICAL AND PRACTICAL TASKS OF PLANT RESISTANCE TO THEM

6

N.A. MIKHAYLOVA, U.B. SCHUROVENKOV, All-Russian Research Institute for Plant Protection, Ramon, Voronezh, USSR

In the integrated wheat protection system for solving problem of resistance to *Eurygaster integriceps*, *Trigotylus coelestialis* and *Haplothrips tritici* we used the rich collection of All-Union Institute for Plant-Growing and unique natural wild wheats and their relatives in Armenia. It turned out, that wild wheats do not possess resistance peculiarities, because the latter were not the possess resistance peculiarities, because the latter were not the selection factors.

Relatively resistant species were found among primitive wheats. It was determined that only plant structural peculiarities may be the most reliable resistance factors, the same about other cereal crop resistance.

On the basis of results obtained we determined wheat variety model resistant to sucking insects. Our methods turned out to be rational and effective and may be used for solving resistance problem of other crops.

## **R20.5.** Hormonal regulation of the sunn pest (*Eurygaster integriceps* Put.) reproductive development.

7

Burov V.N., Kozhanova N.I., Sadikova G.I., Shinyaeva L.I.  
All-Union Plant Protection Institute, Leningrad, USSR

JH-I is the prevailing form of the juvenile hormones during the *Eurygaster* ontogenesis including imaginal period. Soon after metamorphosis the reproductive diapause is coming but the JH titer in the hemolymph remains high due to the deposition of the connected hormone in the fat body. During the diapause when the JH titer in the organism is low the reproductive development is going on: the high level of DNA synthesis in the germaria of the females and slow transformation of the spermatocytes into spermatids and spermatozooids are observed. Vitellogenesis, the development of accessory sex glands of males and females and the stimulation of the sex pheromone production are observed in the postdiapause period when JH titer in the hemolymph is increasing. The hormonal balance alteration by the way of allatectomy or exogenous JH application shows different dependence of various gametogenesis stages on the JH titer. In females the previtellogenesis does not need JH regulation whereas the vitellogenesis is carried out only under JH control. In males the premeiotic stages of spermatogenesis are JH undependable while the hormone shows stimulating influence on the spermatid differentiation.

R20.5.  
8

## TEACHING IPM TO SMALL-SCALE RICE FARMERS IN THE PHILIPPINES

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Pest monitoring services provided by governments or paid consultants are impractical for the large number of farmers cultivating small holdings in developing countries. The farmers themselves must be taught the techniques of IPM -- pest recognition, measurement of abundance, and control decisions. Farmers can most efficiently be guided if they form groups of 15-25 and choose a leader. Weekly 2-hour meetings with farmer leaders and the extension technician during the growing season provided the continuous support farmers needed to adopt IPM technology. One technician can serve eight villages of 100-200 farm families each.

R20.5.  
9

## CROP LOSS ASSESSMENT IN IPM TRIALS ON RICE IN THAILAND

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Four rice varieties were grown in field experiments in dry season 1982 and wet season 1983 under 3 treatments or levels of insect control : check (no insecticide), integrated pest management (IPM), and maximum protection. Population buildups of brown plant hopper (*Nilaparvata lugens*) in dry season 1982 were similar in all treatments but reached economic proportion in the susceptible variety RD 7. Dead hearts caused by yellow stemborer (*Scirpophaga incertulas*) were significantly higher in the check treatment for all varieties. The IPM treatment yielded 4.8 times more and the maximum protection 4.3 times more than the check treatment. In wet season 1983 there were no differences in yields and pest incidences.

**R20.5.** CONTROL OF THE INITIAL INFESTATION OF FIELD BEANS BY THE BLACK  
**10** BEAN APHID *Aphis fabae* IN THE SCOPE OF INTEGRATED PLANT PRODUCTION

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Establishing a strong population of beneficial insects early in the year is important for the integrated production of field beans and especially for the control of the black bean aphid *Aphis fabae* SCOP. (Hemiptera, Aphididae). The biocenosis can be stabilised, and the danger of an outbreak can be diminished.

Moreover, cultural methods are of great importance. In the field trials that are hereby reported the influence of soil covering to the patterns of the primary infestation is analysed.

Variation of seed density, mixed cropping with clover and gras varieties and variation of dates of sewing were done for this purpose. The population dynamics, control methods and secondary distribution is discussed.

**R20.5.** ADVANCES IN INTEGRATED AND SUPERVISED CONTROL OF PROTECTED  
**11** CROPS IN SICILY

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The results of researchs and development on integrated and supervised pest management for greenhouse whitefly (*Trialeurodes vaporariorum* (Westw.)), leafminers (*Liriomyza brioniae* (Kalt.), *L. trifolii* (Burg.)), red spider mite (*Tetranychus urticae* Koch) and other minor pests in the non-heated plastic houses in Sicily are summarized.

The crops involved are tomato, eggplant, vegetable marrow, sweet pepper, kidney-bean, strawberry, rose and gerbera.

Trials carried out in Sicily from 1979 forwards demonstrated that yellow sticky traps alone can effectively protect in Autumn tomato and eggplant crops from whitefly, if they are exposed at the first sign of adult presence; on established whitefly populations in the Spring sticky yellow traps and one or two treatments with quinomethionate are necessary to depress the whitefly infestation. In this case naturally introduced populations of chalcid wasp *Encarsia formosa* can build up on the surviving whitefly progeny despite the presence of the traps or of these and two quinomethionate treatments.

A supervised control carried out in 1982-83 by alternative deltamethrin and quinomethionate sprays are successfully against major and minor pests and can be satisfactory applied where the growers do not like apply the integrated pest management. They are not compatible with biological control.

GUAN-SOON LIM<sup>1</sup><sup>1</sup>MARDI, SERDANG, SELANGOR, MALAYSIA

In Malaysia, the diamond-back moth (DBM) is a key pest of cabbages with chemical insecticides constituting the only control measure. Consequently, numerous problems have resulted, viz: (1) development of resistance in the pest, (2) increase in incidence of chemical poisoning of farmers, (3) presence of chemical residues on marketed produce, (4) hazards to wildlife and (5) rapid rise in cost of crop production. Arising from these have thus emerged a strong need for a more rational outlook; hence the integrated pest management (IPM) approach.

Initial development of the IPM programme was aimed essentially at reduced use of insecticides while maintaining crop yields and/or revenues. In such an attempt, the insecticides were employed only when necessary as guided by tentative economic thresholds. The feasibility of such a programme encompassing the integration of permethrin, Bacillus thuringiensis, parasitoids and pheromone traps was evaluated against the farmers' pest control practices in which cabbages were sprayed against DBM at 3-4 days intervals. Preliminary findings based on nett revenue attained as well as the overall reduction in the number of insecticidal applications per crop showed that the IPM programme was generally superior to the farmers' prophylactic practice. However, there were indications that IPM may not always be optimal, being also governed by the degree of DBM infestation, damage by other pests and diseases, and price fluctuations.

## R20.6. CONTROL OF THE OLIVE FRUIT FLY BY MASS TRAPPING 1

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The efficacy of mass trapping for the control of the olive fruit fly, *Dacus oleae* (Gmel.), was tested for three years in Greece. Food, color and sex attractants were combined on the traps which were either sticky or insecticide treated boards.

The results showed that satisfactory olive protection is possible provided that fly immigration to the protected orchard is restricted and environmental conditions do not allow high reproductive rates of the insect. Under conditions favorable for the insect, a late bait spray is required in addition to mass trapping for adequate crop protection. The above results were obtained in orchards with imperfect isolation.

**R20.6.**  
**2** PERSPECTIVES OF THE USE OF PHEROMONES AND SEX STERILIZATION TO CONTROL THE APPLE MOTH/ LASPEYRESIA POMONELLA L. IN THE USSR

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Traps with synthetic pheromones for monitoring dynamics of moth flying, signalling timing and necessity of chemical treatments are widely used in the USSR to control the apple moth, *Laspeyresia pomonella* L. Possibility of pest population density decrease by desorientating males and sterilizing natural pest populations, using traps with chemosterilant, is studied. Effects of gamma irradiation (30-35 kr) on moths is compared to effects of chemical sterilization. It is shown that the both sterilizing agents applied at optimal dosages keep sex activity and fecundity of moth at a high level while the population density of progenis is considerably decreased (by 96% - gamma irradiation; by 95% - chemical sterilization). The males sterilized by gamma irradiation and 1% dimatif solution normally inseminated during the first copulation 75.8, 71.9 and 70.4% of females. After the second coupling the same males transmitted necessary quantity of eupyrene sperm to 65.0, 58.8, and 47.4% of females. The release of marked males and their recapture demonstrated that gamma irradiation and dimatif sterilized males were recaptured by pheromone traps in equal measure.

**R20.6.**  
**3** CONTROL OF CODLING MOTH BY DISRUPTION

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Control of codling moth by evaporation of the pheromone (Codlemone) in apple orchards was studied in the Eastern part of Switzerland from 1979-83. The size of the experimental orchards was 0.9 ha (1979-81), 3.5 and 4.5 ha (1982/83).

Codlemone (25 g/ha) was evaporated from impregnated rubber tubes.

The effect of the treatment was measured by

- moth catch in traps
- copulation rate of tethered females
- larval population in the orchard.

Results were compared with data from untreated plots. During the whole period codling moth populations were controlled effectively. In 1983 results were somewhat inferior, probably due to high summer temperatures and rapid evaporation of the pheromone.

## R20.6. VISUAL TRAPS FOR APPLE AND PLUM SAWFLIES

4

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White sticky traps (Type REBEL) were used for 3-4 years in apple and plum orchards to monitor the flight of the apple sawfly, Hoplocampa testudinea and of the plum sawflies, H. flava and minuta. The traps were very attractive and caught up to 80 apple sawflies and 500 plum sawflies per trap and season. Catches started before and ended after bloom. The correlation of trap catches with oviposition was good, especially in apple sawfly. The influence of trap position and weather on the results is discussed. White traps are useful in ecological studies and in teaching. In pest management traps can be used as a complement to the monitoring of oviposition and larval attack. Tentative thresholds are proposed.

## R20.7. COMPARATIVE DEMOGRAPHY OF THREE LABORATORY-REARED TEPHRITIDS IN HAWAII

1

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Life table parameters have been underutilized in monitoring mass production of tephritids which are reared worldwide for sterile insect technique programs. Life table statistics were calculated for the Mediterranean fruit fly, Ceratitis capitata (Wiedemann), the oriental fruit fly, Dacus dorsalis Hendel, and the melon fly, D. cucurbitae (Coquillett) reared on artificial media. C. capitata with the shortest mean generation time ( $T = 31.5$  days) and the second highest net reproductive rate ( $R_0 = 317.5$ ) possessed the highest intrinsic rate of increase ( $r = 0.183$ ). D. dorsalis with the highest  $R_0$  (418.5) but a longer generation time ( $T = 37.4$ ) possessed the second highest  $r$  (0.161). D. cucurbitae with a comparatively low  $R_0$  (255.4) and a long  $T$  (37.3) had the lowest  $r$  (0.149). These demographic parameters are discussed with respect to the simultaneous rearing of all three species in a common insectary in Hawaii.

R20.7.  
2

INFLUENCE OF GAMMA RADIATION AND PLANT EXTRACTS ON THE SEX RATIO OF  
THE MEXICAN FRUITFLY, Anastrepha ludens (Loew.)

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In large fruitfly rearing plants with the purpose of releasing sterile insects into the field as part of an integrated control program or for erradicating an insect species, sex distortion mechanisms in favor of males only or mostly, -- costs of feed, handling and release would be greatly reduced; also sting damage of sterile flies and matings among themselves would be avoided. A. ludens is an important pest of citrus, mango and other fruit grown for exportation -- which must be fumigated before shipment. Ethilene dibromide will be eliminated from the market and no other fumigant is available. Among the best integrated control methods is the release of sterile flies and at least in north-eastern México erradication of A. ludens with this technique is possible. For the above reasons research is being conducted, treating different stages - of the Mexican Fruitfly with low gamma radiation, with plant extracts and other chemicals, evaluating their effect on the sex ratio of adults. Results of - - this work will be presented.

R20.7.  
3

GAMMA IRRADIATION OF THE MEDITERRANEAN FRUIT FLY: EFFECTS OF  
NITROGEN INDUCED HYPOXIA ON FEMALE FERTILITY.

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Female Mediterranean fruit flies (medflies), Ceratitis capitata (Wied.) were known to have a lower tolerance threshold than the males to sterilizing doses of gamma radiation. Infecundity in females was accomplished at ca. 1/2 or less of the 10 krad dose required to achieve almost complete male sterility in air atmosphere. Best advantage in accomplishing sterility was to irradiate pupae -2 days (prior to eclosion) and to avoid anoxic conditions immediately before and during exposure to gamma rays. This recommendation was used in sterile-insect release (SIT) programs.

Subsequent research produced an alternative and revealed advantages in causing anoxia during the sterilization process. Competitiveness factors could be improved by oxygen removal. Although higher radiation dose was required to achieve 99.5% or above male sterility, the technique safely rendered the females infecund at -2 days pupal eclosion. Research focused on male sterility and improving competitiveness and nitrogen anoxia effects on female flies was not studied in detail. Hypoxic conditions which protect somatic tissue in adults appear related to the cause of fertility which occurs among eggs oviposited by irradiated female flies. Release of reproductive females in sterile-insect programs must be avoided. Germ cell development following irradiation in nitrogen on female medfly reproductive capacity are described and implications in SIT are discussed.



**R20.7.** EVALUATION OF GAMMA-IRRADIATION DOSES ON SURVIVAL AND FERTILITY OF  
**4** GLOSSINA PALPALIS PALPALIS (DIPTERA, GLOSSINIDAE)

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With all irradiation doses from 3 to 21 krad treatment in nitrogen atmosphere applied to 29 day old puparia of Glossina palpalis palpalis, survival rate of the males was similar during the first 20 days of adult life. The effect of different treatment doses became apparent after this age, particularly with higher irradiation doses. Males subjected to 12, 15 and 18 krad irradiation treatment in air had survival rates of 72.0%, 31.8% and 3.6% respectively at 40 days post-emergence. In comparison similar irradiation treatment in nitrogen atmosphere resulted in survival rates of 81.4%, 71.4% and 60.5% respectively. The survival and sterility of males subjected to 12 krad treatment in air was similar to those with 15 krad treatment in nitrogen atmosphere. Emergence rate, survival and viability of the emerged flies from puparia subjected to 12 krad in air were age-dependent. No fly emergence was observed from puparia younger than 15 days. Whereas puparia treated at the age of 25 days and above, showed normal pattern of adult emergence, survival and reproduction. Generally females appeared to withstand high irradiation doses without adverse effect on their survival than males and low irradiation doses such as 6 krad in nitrogen caused failure of the ovaries to develop after the ovulation of A1 and C1 eggs in treated females.

**R20.7.** MULTIPLE MATING AND MIXED INSEMINATION BY FERTILE AND STERILE SPERM IN  
**5** GLOSSINA PALPALIS PALPALIS (DIPTERA, GLOSSINIDAE).

TENABE, S.O. & MCHAMMED, A.N.

N.I.T.R., VOM & AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA.

The influence of female age and the duration of intervals between successive copulation on female fecundity in Glossina palpalis palpalis was examined. Results showed that the propensity for multiple mating was similar when females were given alternate mating chances with sterile or fertile males from 3 mating tests carried out within an interval of 24 hours when females were 3 days old. The first mating is however the most important, irrespective of the type of male used first. Nevertheless, mating subsequent to the first, did influence the final fertility of the female, irrespective of the male type that performed the first mating test. It would appear that there was restricted chance that multiple mating could result in uptake of a substantial amount of mating products from the second or third mates. There was gradual decrease in the receptivity of females subjected to three matings with fertile or sterile males. Females older than 8 days were less receptive to multiple mating. Therefore the possible effect of multiple insemination may be restricted to females younger than 8 days. Where multiple insemination occurred the sterile sperm from males treated with 12 krad dose in air were found to be competitive with fertile sperm. Therefore multiple mating and mixed insemination are not likely to have detrimental effect on the success of a control programme involving the use of sterile Insect Technique on G.p. palpalis.

**R20.7.** EFFECT OF GAMMA IRRADIATION ON MATING COMPETITIVENESS OF THE GREASY  
**6** CUTWORM, AGROTIS IPSILON (HUFN.) (LEPIDOPTERA : NOCTUIDAE)

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The competitiveness values of males of Agrotis ipsilon (Hufn.) irradiated with 150 Gy were more than those irradiated with 250 Gy. Increasing the competition ratio resulted in the increase of the sexual competitiveness.

Females irradiated at 150 Gy were more competitive than those irradiated at 200 Gy. The calculated competitiveness values were fully competitive with the substerilizing and sterilizing doses at the different ratios.

**R20.7.** THERMOSTERILIZATION OF THE EGYPTIAN COTTON LEAF WORM,  
**7** SPODOPTERA LITTORALIS BOISD.

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IN THE LIGHT OF RESULTS OF ORIENTATION TESTS, ONE DAY-OLD PUPAE OF SPODOPTERA LITTORALIS WERE EXPOSED TO 38° C., FOR 24 HOURS. TEN PUPAE OF EACH SEX WERE TREATED AND A SIMILAR NUMBER WAS USED AS CONTROL. INTER-CROSSING BETWEEN NEWLY EMERGED MOTHS WAS ACHIEVED. OVIPOSITION RATE AND HATCHABILITY OF EGGS WERE OBSERVED AND TAKEN AS A PARAMETER OF FECUNDITY.

COMPUTATION OF RESULTS REVEALED INDUCED STERILITY DUE TO EXPOSURE OF PARENTAL PUPAE TO EXTREME TEMPERATURE. THIS EFFECT WAS MORE PRONOUNCED IN THE GROUP WHERE TREATED MALES WERE CROSSED AGAINST UNTREATED FEMALES, INDICATING THAT MALES ARE MORE RESPONSIVE TO THERMOSTERILIZATION THAN FEMALES.

## R20.7. 8 STERILITY EFFECT OF BISAZIR ON A POLYPHAGOUS PEST

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Epilachna vigintioctopunctata, Fabr. is a polyphagous pest. It is the habit with the adults and the grubs to feed voraciously leaves and tender parts of the plants by scraping their chlorophyll. Severe infestation results in premature destruction of foliage. The present work has been undertaken to find out the effect of bisazir on the fecundity and fertility of Eplachna. Male requires lesser dosege of sterilant than female to produce the same percentage of sterility. The complete sterility was obtained at 0.1% of Bisazir treatment and above this concentration.

## S20.2. 1 STRUCTURE AND ORGANIZATION OF ARTHROPOD COMMUNITIES ON AGRICULTURAL CROPS: INFLUENCE ON BIOLOGICAL CONTROL

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An arthropod community is most simply but under defined by stating that it is an association of arthropod species within a given area or on a particular habitat. On agricultural crops the "kind" of community that forms, composed as it is of interacting phytophagous and predaceous-parasitoid species, determines both the potential for damage and that for successful biological control. In the present perspective, two principal relationships determine arthropod community organization, development and persistance. First, there is a conformity between the "kind" of arthropod community present and the community habitat or crop developmental pattern. Second, the arthropod communities that form on agricultural crops are drawn from the species pool which is composed of arthropods capable of colonizing the crop of interest (component community) from outside sources (compound community). Three features of the community habitat are discussed as these contribute to the formation of particular arthropod complexes. These include: (1) changes in architectural complexity of the plant (crop) habitat both annually and through longer time periods; (2) chemical components of the community habitat which either enhance or depress arthropod richness or biomass and; (3) modification of the community habitat through cultural activities including the use of pesticides. The concept of the species pool is pursued with special emphasis placed on its structure and organization as these influence the potential for biological control in agricultural systems.

## S20.2. 2

### THE DYNAMICS OF HOST-PARASITOID-INSECTICIDE SYSTEMS.

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While it is generally accepted that many insecticides are antagonistic to the action of natural enemies in the control of pests, the dynamics of host-parasitoid systems in the presence of insecticides remains virtually unexplored. Analytical models of host-parasitoid interactions are described where there is a regular insecticide application each generation. These reveal the impact on host equilibrium levels and stability properties of different application strategies. Four possibilities are considered.

- (1) Insecticides act prior to parasitism and only kill hosts.
- (2) Insecticides act after parasitism and only kill hosts.
- (3) Insecticides act after parasitism and also kill parasitized hosts.
- (4) Insecticides act prior to parasitism and also kill adult parasitoids.

There is a clear ranking of these different application strategies in terms of the depression of the host equilibrium and their contribution to stability. These models may be used to explore the importance to IPM of (1) the timing of insecticide application in the pest's life cycle, (2) the relative toxicity of the insecticide to pest and parasitoid and (3) the relative value of methods which avoid mortality of adult parasitoids (e.g. parasitoid resistance and microbial insecticides).

## S20.2. 3

### BIOCHEMICAL ASPECTS OF CHEMICAL SELECTIVITY

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Arthropods utilize a variety of enzyme systems as defense mechanisms against dietary xenobiotics and insecticides. Among these enzyme systems are mixed function oxidases, esterases, glutathione S-transferases and cis-trans-epoxide hydrolases. The detoxification system(s) most utilized by a species depends on its biology and feeding habits. Plant feeders have efficient oxidative detoxifying systems; predators rely to a greater extent on esterases and glutathione S-transferases. Based on these differences hydrolytically detoxified insecticides are relatively safer for predaceous species than are insecticides detoxified oxidatively and therefore, more likely to be compatible with integrated pest management systems. Synthetic pyrethroids and certain phosphorothiolates are examples of insecticide types that are compatible with IMP.

## S20.2. ECOLOGICAL SELECTIVITY THROUGH DOSAGE, APPLICATION AND TIMING 4 TECHNIQUES

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Broad-spectrum pesticides have been and will continue to be for the foreseeable future one of the most powerful and effective tools available for the management of pest populations. Due to the high cost currently associated with pesticide development and registration, the prospects for the development of narrowly selective chemicals appear slim. Despite the many serious problems arising from the use of broad-spectrum pesticides, (e.g. destruction of natural enemies), these materials continue to be the foundation upon which many integrated pest management programs utilizing biological control are constructed. Serious efforts have been made to maximize the benefits of these materials while minimizing their adverse effects. This can be accomplished through the selective use of such materials in a manner that ensures contact of a toxic dose with the target species and minimizing contact of a toxic dose with natural enemies. Such intelligent use of pesticides is termed ecological selectivity. Achieving such pesticide selectivity can be obtained in special ways: (1) by modifying dosages, (2) by careful placement on the plant, and (3) by specific timing. A number of integrated pest management programs on deciduous tree fruit crops as well as other crops are successfully using such techniques to conserve natural enemies while maintaining harmful pests below their economic injury levels. A review of research findings and current thinking on using broad-spectrum insecticides in a selective manner compatible with natural enemies will be discussed.

## S20.2. THE USE OF INSEGAR<sup>®</sup>, A SELECTIVE INSECT GROWTH REGULATOR, 5 IN INTEGRATED CONTROL PROGRAMMES OF OLIVE AND CITRUS TREES

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Populations of Ceroplastes floridensis Comstock, Saissetia oleae (Olivier) and S. hemisphaerica Targ. (Homoptera: Coccidae) infesting citrus and olive trees were effectively controlled by treatments of Insegar (phenoxy carb) at the cons. of 0.003 to 0.025% a.i., depending on pest developmental stage. Field and laboratory applications of Insegar revealed no adverse effect on the development and/or activity of 5 hymenopterous ecto- and endoparasites of 3 diaspid; 2 endoparasites of S. oleae and 2 egg-predators of coccids. Feeding of Chilocorus bipustulatus L. (Coccinellidae) on Insegar treated armoured scales at the rate of 0.025% a.i., did not arrest larval development but inhibited pupation; fecundity of sexually mature females was not affected but egg hatch was completely inhibited; egg viability was regained when Insegar-exposed beetles were transferred to an uncontaminated environment. The use of Insegar (R0 13-5223) is compatible with IPM programmes since the chemical exhibits high degree of selectivity toward scale insect parasites and semi-selective characteristics toward coccinellids.

**520.2.** INTERFACING PESTICIDES WITH THE SUCCESSFUL BIOLOGICAL CONTROL COMPLEX  
**6** OF LIRIOMYZA SPP. LEAFMINERS INFESTING APIUM AND LYCOPERSICON SPECIES

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In the absence of pesticide application, L. trifolii and L. sativae populations infesting A. graveolens and L. esculentum are effectively suppressed by a complex of six parasite species. Unfortunately, chemical treatments used to control lepidopterous pests reduce parasite density, resulting in an economically damaging resurgence by Liriomyza spp. Field-orientated investigations of several compounds, including methomyl, methamidophos, cyromazine and avermectin, have indicated that the species composition of the parasite complex is altered by the chemicals chosen. Additional research has documented the relative effectiveness of each parasite species, and the effect of plant species and leafminer host-species on the composition of the total parasite complex. Thus, selection of chemicals for use in an IPM program can be tailored to fit both the crop and the parasite complex present. Also, these results offer considerable insight into selection of the most suitable parasites for introduction from the U.S. into Europe and Africa.

**520.2.** ASSAYS FOR INSECTICIDE TOLERANCE IN PARASITES OF APHIDS  
**7**

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Dipped glass vials and sprayed leaves were used to evaluate the initial toxicity of insecticides to aphid parasites, mainly Diaeretiella rapae. Initial toxicities were determined by exposing 1 to 3 day-old adult parasites to freshly dried deposits in glass vials. Persistence of the insecticidal residues was tested by spraying of radish plants grown under outdoor conditions and exposing 1 to 3 day-old adult parasites to the treated leaves 1,2,4,8,16 and 32 days after application. Insecticides differed remarkably in their initial and residual toxicity. Diazinon was one of the most toxic insecticides and residual deposits of permethrin were of relatively low toxicity. When mummified aphids were sprayed adult emergence differed greatly depending on lipophilic properties of insecticides. Survival and fecundity of D. rapae adults were studied with sublethal dosages of various insecticides.

**520.2.** DETECTING VARIABILITY AND SELECTING FOR PESTICIDE RESISTANCE  
**8** IN TWO SPECIES OF PHYTOSEIID MITES

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Methods used for evaluating the effects of pesticides and selecting for pesticide resistance in phytoseiid mites are reviewed from recent literature. In particular slide dip, leaf dip, and leaf disc spray methods are compared. Also selection of mites on plants is compared with selection of artificially bred mites.

The selection of two predatory mites (Typhlodromus pyri and Phytoseiulus persimilis) for resistance to three synthetic pyrethroids is described. Tolerance of field populations to all three SPs was low in P. persimilis but moderate in T. pyri. Field samples of both mite species were sprayed on leaf discs and survivors were reared in laboratory and/or glasshouse cultures. These cultures were sprayed with repeated doses of SPs; initially T. pyri was selected with cypermethrin and P. persimilis with fenvalerate. The survival rate of T. pyri increased at each selection. After three selections the dose of cypermethrin was raised 2½ times and % survival was three times higher than that for the field population sprayed at the same dose. Selection with cypermethrin is continuing. Tests for cross-resistance to the other SPs and genetic analysis may indicate whether resistance to SPs is indeed present in this T. pyri population. In the first 12 months repeated selections of P. persimilis with fenvalerate gave no perceptible change in survival rate.

**520.2.** DETECTING VARIABILITY AND SELECTING FOR PESTICIDE RESISTANCE IN THE  
**9** COMMON GREEN LACEWING, CHRYSOPELLE CARNEA

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Chrysoperla carnea adults were collected from alfalfa fields throughout California, USA. Both adults and their larval progeny were screened with two carbamates, carbaryl and methomyl; two organophosphates, diazinon and phosmet; and two pyrethroids, permethrin and fenvalerate. Green lacewing populations exhibited variation in their responses to all of the pesticides tested, indicating substantial intraspecific variability. The C. carnea larvae from Imperial Valley (along the southern border of California) were the most tolerant and were used as a base colony for laboratory selection for carbaryl resistance. Within 3 generations of selection of larvae mortality was reduced from more than 90% to less than 30% at field rates of carbaryl. Thus, C. carnea has been successfully selected for carbaryl resistance in the laboratory.

## S20.2. SCREENING FOR PESTICIDE RESISTANCE IN APHYTIS. 10

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Pesticide resistance in arthropod pest species has become widespread and poses serious problems. Similar resistance in natural enemies, although very desirable for integrated pest management programs, has been demonstrated in very few cases.

Existing test methods were found to be inadequate for important biological control agents, many of which are minute, delicate and highly active parasitic Hymenoptera. In a novel exposure method, dyed sucrose solutions containing graded concentrations of insecticide were used so as to combine stomach and contact poison effects. Results were subjected to probit analysis by computer.

No significant resistance to malathion was detected in 7 stocks of Aphytis holoxanthus DeBach, obtained in Israel from citrus groves subjected to repeated malathion applications. No partial or incipient resistance was indicated in limited selection experiments.

## S20.2. PESTICIDE-RESISTANT NATURAL ENEMIES IN IPM SYSTEMS 11

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Laboratory selection and small plot tests of pesticide resistant strains of the phytoseiid, Metaseiulus occidentalis, were conducted during 1979 and 1980. During the past 3 years, the feasibility of implementing these strains was evaluated in commercial almond orchards in California. Large scale implementation required developing several tools: mass rearing capabilities, release techniques, sampling and prediction capability. The long term persistence of the carbaryl-OP and carbaryl-OP-sulfur resistant strains was evaluated, and the role of aerial movements into and out of orchards considered. The resistant strains established, dispersed, persisted, overwintered, and controlled spider mites in commercial almond orchards during 1981-83. Long term biological control by these predators seems likely as long as disruptive pesticides are not applied.



**S20.3.**  
**2**

## THE GENETIC CONTROL OF THE AUSTRALIAN SHEEP BLOWFLY *Lucilia cuprina*

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The feasibility of controlling the Australian sheep blowfly, *Lucilia cuprina* by genetic means has been under investigation since 1967. Two main systems have been studied; (a) use of compound chromosomes and (b) the use of Y-auto-some translocations coupled with conditional lethals. Strains incorporating both concepts were developed by 1975 and a series of ecological studies were conducted between 1971-1980 aimed at providing basic information on population densities, migration rates, the relationship between fly abundance and incidence of myiasis on sheep, overwintering characteristics etc. These studies were drawn together in a series of field trials between 1976-1978.

The field trials revealed a number of significant technical weaknesses in mass rearing procedures, strain stability, release techniques, and fly competitiveness. The trials also revealed methodological shortcomings in our ability to determine precisely what the impact of the releases were in terms of genetic load induced, and its effect on fly abundance and myiasis incidence. Furthermore, the trials indicated the existence of strong laboratory selection under mass rearing conditions for genes which affected competitiveness of released insects. Many of the problems listed above have been resolved and further major field trials are scheduled for the 1984-85 field season.

Recombinant DNA techniques are also being explored as an adjunct or alternative to classical chromosome mechanics for developing methods of controlling *L. cuprina* by genetic means. One example of this project is given.

**S20.3.**  
**3**

## MEDFLY ERADICATION IN EGYPT: INITIATION OF ANOTHER LARGE SCALE STERILE INSECT FIELD PROGRAMME

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Modelled after the successful MOSCAMED PROGRAMME in Mexico, the MISR-MED Project in Egypt is a joint venture between the Intl. Atomic Energy Agency and the Egyptian Ministry of Agriculture. Its ambitious goal, the eradication of the mediterranean fruit fly from all of Egypt using the sterile insect technique, is feasible not only technically, due to Egypt's island geography, flat topography and pattern of agriculture, but is also economically very profitable. Conservative evaluations of project cost/benefit, show high internal rates of return, without taking into account the future expansion of fruit producing areas, the increase of export competitiveness, and environmental benefits due to the reduction of insecticidal residues.

The 1000 million a week sterile fly mass production facility, presently under construction at El-Amriya, is described, as well as the project organization, training of personnel, eradication strategy, and planned cooperation after achievement of eradication with other countries in the region.

**520.3.** THE USE OF STERILE PINK BOLLWORM FOR PREVENTION OF THE SPREAD INTO  
**5** THE SAN JOAQUIN VALLEY OF CALIFORNIA

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The sterile insect technique has been used to prevent the establishment of the pink bollworm, Pectinophora gossypiella (Saunders) in the San Joaquin Valley of California since 1967. Evidence of movement of significant numbers of nonsterile insects into the Valley is presented. The biotic potential of this pest has been established yet damaging populations have not developed.

The need for improved competitive values of our release insect has been established.

Progress in sterile insect improvement to provide a more competitive insect is reported.

**520.3.** INTEGRATED CONTROL OF CATTLE WARBLER, HYPODERMA SP., IN THE UNITED  
**6** STATES

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A joint Canada-United States study was initiated in 1982 on a site contiguous to the Montana-Alberta boundary to evaluate integrated pest management (IPM) of cattle grubs, Hypoderma lineatum (L.) and H. bovis (DeVillers). The project objectives of the 5-year study are 1) to determine whether the use of systemic insecticides combined with release of sterile heel flies will eliminate cattle grubs from a defined area; 2) to determine if such eradication is feasible in an area containing both species; 3) to evaluate the economic benefit of cattle grub IPM to the cattle industry. More than 22,000 head of cattle were treated with 20% fenthion Spotton® the first year with a 99% reduction of grubs when compared with untreated cattle. Grubs surviving treatments were found in 9.2% of the cattle with a mean of 1.4 grubs/animal. About 27,000 animals were treated the second year. A total of 1200 H. lineatum and 1000 H. bovis 3rd-instar larvae were collected, reared to adults, sterilized, and released onto the treated area in 1983.

### **S20.3.** STATUS OF THE STERILE INSECT TECHNIQUE (SIT) FOR CULEX TARSALIS **7**

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UNIVERSITY OF CALIFORNIA, BERKELEY, CA. 94720, U.S.A.

Pilot field tests with released radio-sterilized Culex tarsalis males indicated that treated males taken from the field as pupae are competitive against field males while laboratory reared males are not.

Mating behavior differences between the two types of males appear to relate to differences in pre-mating flight (swarming) patterns which in turn result from a laboratory rearing environment. Current studies are directed to eliminating, or minimizing, conditions in the laboratory which contribute to the poor flight capability of laboratory reared males as noted in flight-mill studies.

### **S20.3.** COMMERCIAL CONTROL OF THE ONION FLY DELIA ANTIQUA (DIPTERA: ANTHOMYIIDAE) BY THE STERILE INSECT TECHNIQUE **8**

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'de groene vlieg' Duivenwaardsedijk 1, 3244 LG Nieuwe Tonge, Holland

In 1981, after fifteen years of governmental research, the sterile insect technique was introduced in Dutch agriculture by the firm 'the green fly', as a control agent against the onion fly. Commercial control is possible due to the combination of the spatial distribution of onion fields and the migration pattern of onion flies. Nearly any single field can be treated separately, with often only one release site per field. Eradication is not aimed at. If this unstable situation had been reached, one would still need intensive monitoring. Already the cost of estimating low population levels exceeds the cost of a standardized control.

The onion fly in the Netherlands has two major flights. Control concerns the first flight only. Both to link up with chemical control and to estimate the wild population level releases start during the second flight in the preceding year, from sheer necessity free and not obliging. Farmers join the sterile insect technique because of cost (for about half of them it is cheaper), environmental concern, or undesirable effects of the insecticide on onions or even on the grower himself. The area treated increased from 50 ha in 1981 to 1200 ha in 1983 with a local participation of 65%.

Sterilized flies are released as adults, ♂ and ♀, by plane: flight height 20 m, speed 120 km/h, treating up to 100 onion fields (average size 4 ha) per hour. For control releases are weekly. Progress of control is checked regularly with very simple traps, recapturing about 1/4 per thousand of flies each.

**520.3.** AN INTEGRATED CAMPAIGN AGAINST 3 TSETSE SPECIES IN AN AREA  
**11** SOUTH OF BOBO-DIOULASSO, UPPER VOLTA, WEST AFRICA.

BURKHARD BAUER

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The combination of a trapping system of insecticide impregnated screens and biconical traps followed by the release of sterile males led to the complete control of Glossina palpalis gambiensis and G. tachinoides in the agropastoral zone of Sideradougou. This area, south of Bobo-Dioulasso, covers approximately 3000 km<sup>2</sup>. During 4 months of the dry season 6500 insecticide impregnated screens along more than 650 km of rivers reduced the riverine tsetse population by 94 %. To produce sterile males more than 150000 (G. p. gambiensis) and 100000 (G. tachinoides) females were maintained in industrial colonies. After reduction of the natural population the releases of sterile males followed during the rainy season in 1983. 35 sterile males per km of river were sufficient to attain the planned ratio of 7 sterile males to 1 wild male. Wild flies could not be detected during the most recent survey in April 1984. Barriers of biconical traps along the principal river systems prevented reinvasion of the 2 riverine species. Against G. m. submorsitans transsect barriers of insecticide impregnated biconical traps and screens were effective. Releases of sterile males produced by a colony of 50000 females were started in early 1984. Releases of all species will continue until the end of 1984.

**520.3.** FRUIT FLY ERADICATION PROGRAM BY S.I.T. IN JAPAN  
**15**

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We have attempted to eradicate destructive fruit flies from southern islands in Japan by using S.I.T. which brought a successful eradication of the melon fly from Kume Island in Okinawa in 1977. In Kagoshima Prefecture, sterilized melon flies have been released since Aug. 1981 on Kikai Island. The percentage of host fruits infested by the fly became zero in November 1982, and any infested fruits have not been found on the island thereafter. At the moment, we are planning to expand our eradication program to the neighbouring larger islands in the Amami Island Group. For this purpose, we are now constructing mass-production facilities on Amami Island which can provide 30 million pupae per week. Similar programs have also been performed to eradicate the melon fly from Okinawa Prefecture and the oriental fruit fly from the Ogasawara Islands in Tokyo.

**S20.4.** INFLUENCE OF PLANT ALLELOCHEMICALS ON THE SURVIVAL AND  
**1** DEVELOPMENT OF INSECT PARASITOIDS

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Although many aspects of these biochemical/ecological interactions have been studied, little attention has been given to the influence of these plant biochemicals, on the survival, development and effectiveness of the herbivore's natural enemies. Our initial investigations and a limited number of studies in the scientific literature suggest that allelochemicals in the diet of herbivores may be deleterious to their parasitoids. Such effects may have a significant impact on our understanding and evaluation of the effectiveness of parasitoids and on the use of resistant cultivars, which may effect both pest herbivores and their natural enemies.

**S20.4.** BROAD SPECTRUM DETERRANCY OF CHRYSOMELID DEFENSIVE SECRETIONS  
**2**

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Larvae of many foliage feeding leaf beetles (Coleoptera: Chrysomelidae) produce defensive secretions from eversible glands lining the thorax and abdomen. Direct and circumstantial evidence indicates that these secretions contain compounds derived from secondary chemicals found in the host plant. Although these chemicals deter attacks by some natural enemies, they are also highly effective in dissuading other herbivores from feeding at the same site as chrysomelid larvae. Therefore, the ecological role of chrysomelid defensive secretions may be as broad spectrum deterrents against the activities of potential competitors and predators alike.

**S20.4.** INFLUENCES OF PLANT PRODUCED ALLELOCHEMICS ON THE HOST AND  
**3** PREY SELECTION BEHAVIOR OF ENTOMOPHAGOUS INSECTS

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The allelochemicals emitted by plants play major roles in the host or prey selection behavior of many entomophagous insects. The presence of these allelochemicals, in many cases, significantly increases the effectiveness of entomophagous insects and thus reduces the survival of herbivorous insects that they attack.

**S20.4.** THE ATTRACTIVENESS OF COTTON VOLATILES TO PARASITOIDS OF  
**4** COTTON HERBIVORES

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Cotton, tobacco and sorghum serve as host plants for Heliothis virescens. We have identified six terpenoids from cotton that are attractive to the parasitoid, Campoletis sonorensis (an ichneumonid that parasitoid H. virescens). Both tobacco and sorghum contain volatile attractants as yet unidentified but different from those of cotton.

While hosts feeding on artificial diet were attractive, hosts were more attractive when feeding on cotton. Frass from cotton fed hosts contained plant terpenoids in addition to host kairomones. The interaction between plants, the third trophic level (parasitoids) and the second trophic level (herbivores) will be discussed.

## S20.4. HERBIVORES, INSECTIVORES, AND PLANT ALLELOCHEMICALS

5

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Plant allelochemical investigations have traditionally focused on the plant-herbivore interface. A growing body of information demonstrates that these plant-derived compounds also play important roles in herbivore-insectivore interactions. For lubber grasshoppers (Romaleinae), sequestered plant allelochemicals appear to be of major importance as predator deterrents. These distasteful insects increase the quantitative and qualitative variation in their defensive secretions through host plant switching, a mechanism insuring that predators will be faced with highly variable antagonistic allomones. The significance of the idiosyncratic defensive exudates vis-a-vis food plants and predators will be discussed.

## S20.4.

6

### EGG PROTECTION BY PARENTAL INVESTMENT OF PLANT ALKALOIDS IN LEPIDOPTERA

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Larvae of an arctiid moth, Utetheisa ornatix, sequester toxic pyrrolizidine alkaloids from host plants. These compounds effectively protect eggs, larvae and adults from a variety of predators. During mating Utetheisa males transfer alkaloids to the female, thereby supplementing the defenses of both females and eggs. In laboratory tests the paternal alkaloid contribution alone proved sufficient to decrease predation by ladybird beetles (Coleomegilla maculata) on Utetheisa eggs. Utetheisa females prefer males possessing an alkaloid-derived pheromone, perhaps thereby selecting mates capable of a nuptial gift of alkaloids.

Many other species of butterflies and moths obtain pyrrolizidine alkaloids during adult visitation to decaying plants. The sex ratio at these alkaloid sources is often strongly skewed. In one male-biased species, Cisseps fulvicollis (Ctenuchinae), males also transfer sequestered alkaloids to the female (and ultimately eggs) during mating. We predict that the acquisition of defensive alkaloids for parental investment in offspring will prove to be a major function of both male and female visitation. The use of alkaloid derivatives as male pheromones in the Danainae, Ithomiinae, and Arctiidae may serve as advertisement of a male's ability to contribute alkaloids during mating.

## 520.4.7 POTENTIAL ROLE OF PLANT ALLELOCHEMICALS IN THE DEVELOPMENT OF INSECTICIDE RESISTANCE

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An increased capacity to metabolize foreign lipophilic chemicals to water soluble and frequently less toxic products is one of many possible biochemical, physiological, and ecological mechanisms that confers resistance in herbivorous insects to synthetic insecticides. Three major enzyme systems are directly responsible for detoxification of both plant allelochemicals and synthetic insecticides, namely the microsomal poly-substrate monooxygenases (cytochrome P-450), esterases, and glutathione S-transferases. The evolution of metabolically resistant insect strains depends on the inheritance of a genetic constitution that provides permanent expression of metabolic capacities sufficient for detoxification. Metabolic capacities can also be temporarily induced by synthetic chemicals as well as by plant allelochemicals. This can result in higher constitutive enzyme activities and also in modified activities by biosynthesis of enzyme forms with modified substrate preferences. A foreign chemical may then be metabolized by a new major pathway. Whereas induction per se does not constitute permanent resistance it may facilitate the development of permanent resistance by allowing sufficient and selective survival for reproduction of individuals with genetically altered but not expressed metabolic capacities. Plant allelochemicals, being capable of inducing higher and/or modified enzyme activities may indirectly contribute to the development of permanent insecticide resistance.

## 520.4.8

Plant secondary substances and the insect/microbe interaction  
May R. Berenbaum

Given that the majority of phytophagous insects house microbial associates, the indirect effects of plant secondary substances on insect biology via actions on microbes are an important consideration in understanding plant/insect interactions. The ways in which plant secondary substances (allelochemicals) affect the relationship between insects and microbes depend upon the relative sensitivity of the two organisms to the allelochemical in question. If microbial sensitivity to the toxin is greater than that of the insect, the observed effect depends upon the nature of the relationship between insect and microbe. In situations in which the microbe is a mutualistic symbiont, the manifestation of selective sensitivity would encompass phenomena ranging from impaired digestion and vitamin deficiency to interruption of pheromone synthesis; in situations in which the microbe is a pathogen, insects can benefit by ingesting plant products that selectively destroy the disease-causing organism. If microbial sensitivity to the toxin is less than that of the insect, pathogens may act to enhance susceptibility of the diseased insect to the effects of the allelochemical by imposing an additional stress on insect metabolism; by the same token, plant-derived substances may enhance susceptibility of insects to microbial diseases via disruption of physiological processes and cell and tissue integrity.



**P20.-** Attractiveness of the egg parasite Trichogramma  
**1** evanescens to some insect sex-pheromones.

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The egg parasitoid Trichogramma evanescens was found to be attracted by some sex insect pheromones.

Two sex-pheromones of Pectinophora (Albamy and PMW, Nomate) gave the highest attractiveness to Trichogramma. The sex pheromone of Earias insulana showed a moderate attractiveness while these of Spodoptera littoralis were the least.

**P20.-** DEVELOPMENT OF AN INTEGRATED CONTROL PROGRAM FOR CABBAGE CROPS IN THE  
**2** NETHERLANDS.

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Cabbage crops are the largest and one of the most valuable field-grown vegetable crops in the Netherlands. Farmers apply up to 10 sprays each season to control pest infestations comprising caterpillars (Mamestra brassicae, Pieris spp.), aphids (Brevicoryne brassicae), root flies (Dehlia brassicae) and some minor pests. A cooperative research program of the Agricultural University, Plant Protection Institute and Horticultural Plant Breeding Institute aims at reduction of the spraying intensity by developing alternative control methods such as a sampling and warning system based on damage thresholds, growing pest resistant plant varieties, and inundative releases of natural enemies (Trichogramma).

**P20.-** Cereal aphid control in winter wheat by red clover underseed: An integrated pest management approach within the Lautenbach-project.  
**3**

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In past years cereal aphids have caused great damage to winter wheat. Instead of chemical control we are searching for a new method to reduce the amount of cereal aphids with undersown trifol in winter wheat. In 1981 and 1982 the population dynamics of *Sitobion avenae* Fabr., *Metopolophium dirhodum* Walk. and *Ropalosiphum padi* L. in herbicide treated winter wheat as well as in undersown comparative fields were investigated. In years with large amounts of aphids there is a decline in aphids to about 50% in the undersown area. The abundance of carabids caught in pitfall traps is not significantly different in both fields. Only *Agonum dorsale* was found in a greater amount in the undersown plots. At the perimeter of the trifolium-plots, however, there are about 50% more staphylinids than in the field without weeds and clover. Collembolans, as well as hymenopterous parasites of the aphids, increase in the undersown plots. In the future we plan to research why the number of aphids at the above-mentioned height decreases.

**P20.-** CHANGES IN PERIPHERAL SENSITIVITY IN ASSOCIATION  
**4** WITH INDUCTION OF FOOD PREFERENCE.

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Dietary experience of plants, or of chemicals in artificial diets, induces changes in the preference of insects for these plants or chemicals and the effect differs between oligophagous or polyphagous species. By correlating the results of electrophysiological and behavioural experiments we have investigated the sensory basis of this phenomenon. We have shown that different mechanisms operate in different insects and that the effect can apply with phagostimulants as well as allelochemicals.

P20.-  
5

ANTIFEEDANT ACTIVITY OF CLERODANE DITERPENOIDS ON  
*Spodoptera littoralis* (Boisd.)

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Antifeedant activity of 9 clerodane diterpenoids isolated from different species of *Ajuga* plants, on larvae of *Spodoptera littoralis* (Boisd.) (Lepidoptera, Noctuidae), have been studied.

Compounds were applied at doses of 50, 25, 10, 1, 0.1 and 0.01  $\mu\text{g}/\text{cm}^2$ . Control of activity was done using the leaf disc method and calculating at different times the feeding ratio (FR) between the consumed area of treated discs (CTD) and that of the control discs (CCD). In order to compare results of different experiments, a  $\text{FR}_{50}$  was defined as the FR at a CCD of 50%.

The most promising compounds were still active at the 0.01  $\mu\text{g}/\text{cm}^2$  dose ( $\text{FR}_{50}$ : 0.1-0.8). Structure-activity relationships are also discussed.

P20.-  
6 PLANT TOXINS DETERMINE BOTH AMOUNT OF PHEROMONE AND SIZE  
OF SCENT ORGANS IN CREATONOTOS (LEP.: ARCTIIDAE) MALES

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<sup>2)</sup>Max-Planck-Institut für Verhaltensphysiologie, 8131 Seewiesen, FRG.

The androconial organs of field-caught males of Cretonotos gangis and C. transiens are strikingly different in size: the eversible abdominal "coremata" (hairy tubes) are between 4 and 30 mm long (i.e. up to .8x wing-span). Correspondingly, the amounts of pheromone produced by these organs vary from 0 to 400  $\mu\text{g}/\text{male}$ . Feeding experiments with laboratory cultures revealed that both coremata morphogenesis and pheromone biosynthesis depend on pyrrolizidine alkaloids (PAs) ingested with larval foodplants. Tests with pure PAs fed quantitatively to individual larvae demonstrate the correlation of the processes. Surprisingly, the secondary plant substances appear to affect the male pheromone system only - no other differences between insects reared with and without access to PAs, respectively, were found, and PA-deficient males mate successfully.

**P20.-** RESISTANCE OF SORGHUM GENOTYPES TO *CONTARINIA SORGHICOLA* COQ. AND *DIA*  
**7** *TRAEA SACCHARALIS* FABR.

F.M. LARA<sup>1</sup> & A.C. BUSOLI<sup>1</sup>

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During the last twelve years many researches about the sorghum [*Sorghum bicolor* (L.) Moench] genotypes resistance to *C. sorghicola* and *D. saccharalis* have been made in Jaboticabal, São Paulo, Brazil. At the same time it was also studied biology, ecology, damage and experimentation techniques related to those pests.

It was observed that the sorghum midge presented cycle in  $16.36 \pm 0.72$  days at Jaboticabal conditions; the major attack intensity occurred at the third superior region of heads and major oviposition was observed at the third day after the beginning of the flowering. The species *Eupelmus popa* Girault, 1917, *Aproctetus diplosidis* Crawford, 1907 and *Tetrastichus* spp. have been observed parasitizing the midge, with the parasitism varying according the varieties. The varieties AF-28, EA-73 and EA-261 showed to be the more resistant to this pest.

About *D. saccharalis* it was observed that 13.3% of infestation may reduce the grain yield in 33.25%. The varieties AF-28, EA-177, CMS x S601 and CMS x S157 showed to be resistant to the sugarcane borer. Others similar researches were made with *Spodoptera frugiperda* and *Schizaphis graminum*.

**P20.-** INTEGRATED PEST MANAGEMENT FOR COTTON PESTS  
**8** IN EGYPT

M. M. HOSNY

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A research programme on the integrated control of cotton pests in Egypt, with emphasis on the use of pheromones and viruses was started in 1979. One successful outcome of the programme has been the development of pheromones for the control of the pink bollworm Pectinophora gossypiella ( by mating disruption ) to the point where practical commercial application is possible; and more than 10,000ha of cotton are being so treated this year (1984). This is the first step towards achieving a comprehensive integrated pest management programme.

Other inputs include the use of nuclear polyhedrosis virus and economic damage thresholds for the control of the cotton leafworm Spodoptera littoralis. All this lead up to the preservation of beneficial insects whose role in controlling Spodoptera and other pests (e.g. Earias, Heliothis, and red spider mites) is evident.



Section 21    **Chemical Control of Insects and Mites** .....

R 21.1.   *Insect Control by Growth Regulators* .....

R 21.2.   *Chemical Control Methods against Agricultural,*  
            *Hygiene, and Storage Pests* .....

S 21.1.   *New Insecticides* .....

S 21.2.   *Natural Pesticides of Plant Origin* .....

P 21.       .....

**R21.1.** EFFECTS OF CYROMAZINE (TRIGARD) ON THE LARVAL AND PUPAL STAGES OF  
**1** LIRIOMYZA TRIFOLII (BURGESS).

GARY L. LEIBEE

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Cyromazine (Trigard, Ciba-Geigy (Corp.)), an insect growth regulator, has been very effective in controlling Liriomyza trifolii (Burgess) on several vegetable crops. In order to use cyromazine more effectively as a pest management tool, this study was conducted to determine dosage related lethal and sublethal effects to the larval and pupal stages. Cowpea, Vigna sinensis (Stickm.) Savi ex Hassk., plants were exposed to ovipositing females for 24 hr and then dipped into 0, 2, 4, 6, 8, 10, 12, and 14 ppm solutions of cyromazine. The plants were maintained at 25°C until larval development was complete. The puparia were collected, counted, and classified according to their morphology as either normal, larviform, or abnormal (other than larviform). Adult emergence was recorded for each group of puparia. The frequency of larviform puparia was directly proportional to dosage. The frequency of abnormal puparia was independent of dosage. Total adult emergence from all puparia was inversely proportional to increasing dosage, with 50% emergence occurring between 2 and 4 ppm. Adult emergence was very low in the larviform puparia (0-33%) compared to the normal puparia (90-100%). Adult emergence in the abnormal puparia was 5 and 0% at 12 and 14 ppm, respectively, and 30-45% at the lower dosages. Application of this information to the management of L. trifolii is discussed.

**R21.1.** STUDIES ON THE BIOLOGICAL EFFECT AND THE METABOLISM OF CYROMAZINE  
**2** IN THE HOUSEFLY

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Cyromazine, CGA-726642, Vetrazin<sup>®</sup>, Larvedex<sup>®</sup> (4-cyclopropyl-1,3,5-triazine-2,4,6-triamine) is an insect growth inhibitor under development by Ciba-Geigy, Ltd. It has shown good activity as a dipterous larvicide and appears to be selective toward dipterous species. The biological effect of cyromazine toward various stages of development in the housefly will be described and the metabolism of cyromazine discussed. Preliminary results on the inhibition of dihydrofolate reductase by cyromazine will be discussed.

**221.1.** RESURGENT EFFECT OF SYNTHETIC PYRETHROIDS AND ANTI-RESURGENT EFFECT OF  
**3** BUPROFEZIN (MOLTING INHIBITOR) ON THE RICE BROWN PLANTHOPPER

O. MOCHIDA, S. L. VALENCIA, and R. P. BASILIO

IRRI, P. O. BOX 933, MANILA, PHILIPPINES

Seven pyrethroids (cypermethrin, deltamethrin, fenvalerate, permethrin, FMC 54800, MTI 11500 & WL 085871) were applied onto IR22 rice plants at rates of 12.5 to 100 g ai/ha on 5, 10, 25, 40, 55, and 70 days after transplanting (DT), respectively. Brown planthopper, Nilaparvata lugens (Hom., Delphacidae), populations were significantly more in plots treated by 3 pyrethroids (deltamethrin, FMC 54800, & WL 085871) than in untreated check plots at 112 DT just before harvest. Those were always lower in plots treated by MTI 11500 than in untreated check. When applied by deltamethrin and other pyrethroids with buprofezin (<sup>R</sup>Applaud), resurgent effect was not observed.

Rice whorl maggot (Hydrellia philippina), deadheart (due to stem borers), leaf folder (Cnaphalocrocis medinalis), and rice bug (Leptocorisa spp.) populations were significantly less in plots treated by all the 7; 5 (deltamethrin, permethrin, WL 085871, cypermethrin & FMC 54800); 1 (deltamethrin); and 1 pyrethroids (deltamethrin); respectively, than in untreated check.

**221.1.** EFFECT OF PRECOCENE AND BENZYL-1,3-BENZODIOXOLE DERIVATIVES ON SEX  
**4** ATTRACTANCY IN THE MEDITERRANEAN FRUIT FLY (DIPTERA:TEPHRITIDAE)

FRANKLIN CHANG AND STELLA C.L. HSU

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Two chromene, 1 related isopentenylphenol, and 20 benzyl-1,3-benzodioxole derivatives, reported to possess potential or documented anti-allatin/anti-JH properties, were tested for their effectiveness in reducing sex attractancy when topically applied to virgin males of the Mediterranean fruit fly, Ceratitidis capitata (Wiedemann). Only precocene II among the chromene derivatives and 5 of the benzyl-1,3-benzodioxole analogs were significantly active ( $p = 0.05$ ) against sex attractancy when bioassayed in a Y-choice olfactometer system. Ninety percent of virgin females treated with the 5 most active benzodioxole analogs, exhibited ovarian abnormalities when examined on day 7 post-treatment. The isopentenylphenol, one chromene, and two benzodioxole derivatives, inactive in our bioassays, were also ineffective in hindering ovarian development. Structure-activity relationships of the tested benzodioxole derivatives are discussed.



**R21.1.** EFFECTIVENESS OF JUVENOIDS AND ANTI-ECDYSONES AGAINST  
**5** THE MULBERRY SCALE, PSEUDAULACASPIS PENTAGONA

B.DARVAS<sup>1</sup> and H.I.ZSELLÉR<sup>2</sup>

<sup>1</sup>Res.Inst.Plant Prot.Budapest and <sup>2</sup>Biol.Cont.Lab.Hmvhely,Hungary

Effectiveness of juvenoids (kinoprene,hydroprene and Ro 13-5223) and anti-ecdysones (triarimol and fenarimol) has been studied against Pseudaulacaspis pentagona (Hom.,Diaspididae).

The chemicals were applied at larval hatching of the first generation of P.pentagona. The best results were achieved by Enstar 5 E and Ro 13-5223 50 WP in 0,1% (a.i.).

The effects were summarised as follows: 1./direct toxicity to the 1st instar (Fenarimol 12 EC and Ro 13-5223 50 WP); 2./abnormal moulting in the 2nd instar (EGYT 2669 20 EC = hydroprene and Ro 13-5223 50 WP); 3./reduction of oviposition rate (Enstar 5 E and Ro 13-5223 50 WP).

The occurrence of Prospaltella berlesei (Hymen.,Aphelinidae) a parasitoid of P.pentagona was strongly reduced by Fenarimol 12 EC (in 0,5% a.i.).

**R21.1.** RESIDUAL ACTIVITY OF PRECOCENE II AND HYDROPRENE AGAINST  
**6** 1st INSTAR LARVAE OF QUADRASPIDIOTUS PERNICIOSUS

B.DARVAS<sup>1</sup>, A.I.FARAG<sup>2</sup>, F.KOZÁR<sup>1</sup> and E.T.E.DARWISH<sup>2</sup>

<sup>1</sup>Res.Inst.Plant Prot.,Budapest,Hungary and <sup>2</sup>Menoufia Univ.,Egypt

Residual activity of precocene II and hydroprene was studied against Q.perniciosus (Hom.,Diaspididae) by treating red current leaf upper surfaces and subsequently infesting them with crawlers after 1, 48, 96 and 144 hours.

With 0.1% (a.i.) conc. total mortality of crawlers placed onto the treated surface within 1 hour was noted with both compounds. 1.0% (a.i.) conc. resulted in a similarly good effect, if crawlers were exposed after 48 hours following treatment.

A level of approx. 50% mortality was observed in 3 days in case of precocene II, used in 0.1% (a.i.) conc. The same conc. of hydroprene induced similar effectivity within 1 day.

## **R21.1.** THE POTENTIAL FOR CONTROLLING COCKROACHES WITH INSECT GROWTH **7** REGULATORS

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Insect growth regulators were evaluated in the laboratory to determine the sublethal effects on cockroaches. Most insect growth regulators induced morphological deformities in cockroaches such as wing twisting and darkened body color. Twisted wing males and females were found to be sterile and males exhibited abnormal mating behavior.

One insect growth regulator, hydroprene, was applied to 100 German cockroach infested apartments. Within 7 months the cockroach population was reduced by 95%. The population began to decline when more than 80% of the population began exhibiting morphological abnormalities indicative of sterility.

## **R21.2.** CYFLUTHRIN AND FENFLUTHRIN, TWO NEW PYRETHROIDS FOR THE CONTROL OF **1** HYGIENE PESTS

W. BEHRENZ AND A. ELBERT

BAYER AG, SPARTE PFLANZENSCHUTZ, ANWENDUNGSTECHNIK, BIOLOGISCHE FORSCHUNG,  
5090 LEVERKUSEN

A description based on laboratory and field studies is given of the biological effectiveness and uses of two new pyrethroids - 1[(pentafluorophenyl)-methyl]-1 R, 3 R-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate (C.A.), proposed common name fenfluthrin, and cyano-(4-fluoro-3-phenoxyphenyl)-methyl-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate (C.A.), proposed common name cyfluthrin. Both active agents have a very broad spectrum of effectiveness. While fenfluthrin has an exceptionally fast knock-down action, which for diptera, and in particular mosquitoes, is significantly superior to that of all other known insecticides, the salient characteristic of cyfluthrin is its residual and ingestive toxic effect, which means that both agents ideally complement each other. Being also environmentally very sound, these two active agents are suitable for use either alone or in combination with each other, or also other active agents, in many forms of application.

## **R21.2.** EFFECTIVENESS OF DELTAMETHRINE AGAINST STORED PRODUCTS **2** INSECTS

Korunić, Z.; Hamel, D.: Institute for Plant Protection, Faculty of Agric. Sciences, 41000 Zagreb, Šimunska 25, Yugoslavia

The initial and residual activity of deltamethrine (K-Othrine CE 25+250 PB) in the dose of 0,5 ppm and pirimiphos methyl (Actellic 50 EC) 4 ppm were tested. Treated wheat was contaminated from time to time with adults (strains from Yugoslavia) of: *Sitophilus granarius*, *S. oryzae*, *Rhyzopertha dominica*, *Tribolium confusum*, *T. confusum*-yugoslavian black Korunić-Sokoloff (mutant), and for the initial activity besides with: *T. castaneum*, *T. madens*, *Palorus ratzeburgi*, *Gnathocerus cornutus*, *Oryzaephilus surinamensis*, *O. mercator* and *Mezium affine*. The obtained results show that deltamethrine and pirimiphos methyl were stable, persistent and effective against tested insects at least 168 days. It was found out that *T. madens* and *T. confusum* were tolerant against deltamethrine. *M. affine* was rather difficult to control. Testing deltamethrine efficacy on larvae *T. confusum* different results were got than on the adults.

## **R21.2.** DELTAMETHRIN IN SPATIAL TREATMENTS **3**

P. CARLE, A. CAUVIN & J.B. NONDEDEO

Deltamethrin can be used by spatial treatment, according to conventional methods or original ones (new aerosols, fumigation, thermo vaporisation).

In spatial treatment in a closed volume, its efficacy at low rates is total, its action is quick and rough with a broad polyvalence. In the atmosphere the persistence is brief; on plants and inert supports, its residual effect, normally shortlived, can be increased. No irritancy and no phytotoxicity is observed.

This use of deltamethrin in closed area is recommended in agriculture for vegetable crops, for the quarantine or for stored products, in agroalimentary field, in public health and in human and veterinary protection.

**R21.2.** A LARGE SCALE PROPOXUR TRIAL AGAINST ANOPHELES STEPHENSI  
**4** LISTON IN HORMOZGAN PROVINCE, SOUTHERN IRAN

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An.stephensi is the main malaria vector in the southern part of Iran as well as in the Indian Sub Continent and Persian Gulf countries. It is resistant to DDT, Dieldrin and Malathion in Iran, and Iraq. A pilot project, using propoxur, 50 per cent W.d.P., was carried out in Bandar Abbas and Minab Shahrestan, Hormozgan province from 1977 to 1983. The known malaria vectors in this area are An.stephensi, An.fluviatilis, An.dthali and An.culicifacies. Annual parasite incidence in this area reported to be 152 per thousand of inhabitant in 1976. In the first year spraying it decreased to 67 and then to 13.2 per thousand in 1982. Susceptibility test carried out on female of An.stephensi prior to this study as well as during the project, ~~showed that~~ this species remain susceptible to this insecticide.

**R21.2.** THE BIOLOGY AND CONTROL OF GRACILLARIID LEAFMINERS ON APPLE  
**5** IN NORTHEASTERN U.S.A.

R. W. WEIRES

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An organophosphate-resistant population of the apple blotch leafminer, Phyllonorycter crataegella (Clemens), was first found in New York orchards during 1974. The spotted tentiform leafminer, Phyllonorycter blancardella (Fabr.), was also found to be resistant in tests conducted during 1977. Both species have three generations per season in this area. The economic threshold level for both species was determined to be two second generation mines per leaf, based on studies evaluating crop load and fruit maturity on several cultivars and seasons. Synthetic pyrethroid insecticides such as fenvalerate, are used prior to bloom to control the adult leafminer moths. The insect growth regulator, alsysin, was also found to be very effective against the leafminer species. This material was also less disruptive to integrated mite control programs than most other materials. Recently the parasite, Apanteles pedias Nixon, was obtained from orchards in Guelph, Ontario, Canada, and released throughout Eastern New York. Hopefully this parasite will provide a greater measure of biological control than presently is found.

**R21.2.** THE EFFECTIVENESS OF CERTAIN INSECTICIDES ON THE BROADBEAN  
**6** LEAF-MINER LIRIOMYZA CONGESTA AND ITS PARASITES AT  
ZAGAZIG REGION, EGYPT.

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FACULTY OF AGRICULTURE, ZAGAZIG UNIVERSITY, EGYPT.

ABSTRACT

The effectiveness of three recommended insecticides, Reldan, Rup and lannate were studied on Liriomyza congesta infestation and percentage mortalities of larval stage and its parasites.

Three to four sprays with Reldan, Rup and lannate could be recommended for control of broadbean leaf-miner in the fields. These insecticides induced significant reduction in the pest infestation and significant increase in its larval mortality.

Lannate gave the lowest effect on the larval stage of L. congesta parasites and Rup had also the lowest effect on pupal stage of these parasites.

Lannate proved to be the most promising insecticide.

**R21.2.** RESPONSE OF THE SPIDER MITE (TETRANYCHUS URTICAE KOCH.), COLLECTED  
**7** FROM THE JORDAN VALLEY, TO NINE ACARICIDES.

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UNIVERSITY OF JORDAN, JORDAN.

Laboratory tests were carried out in the winter of 1982, to investigate the response of the spider mite Tetranychus urticae Koch., to nine acaricides.

Results indicated that cyhexatin and fenpropathrin were leading the other acaricides in their effectiveness, followed by dicofol and methamidphos. Their  $LC_{50}$ 's were 63, 67, 113 and 326 ppm, and resistance factors were 1.6, 1.7, 1.6 and 1.7 folds, respectively. The slopes of the dosage mortality lines were 4.5, 1.8, 1.8 and 1.6 for methamidphos, fenpropathrin, dicofol and cyhexatin, respectively. The tested mite population was homogenously highly susceptible to cyhexatin and fenpropathrin, whereas it was homogenous, less susceptible to dicofol. The population was highly homogenous but intermediate in susceptibility to methamidphos. Relatively, the least effective acaricide was propargite with  $LC_{50}$  of 567 ppm, RF of 10 folds and slope of the dosage-mortality line of 1.4. The tested mite population was homogenously tolerant to propargite.

## R21.2. PROMISING NEW MITICIDES ON CITRUS IN FLORIDA

8

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During 1978 to 1984, over 70 pesticides were evaluated in various replicated field trials on citrus for the control of the citrus rust mite, Phyllocoptruta oleivora (Ashmead) or the citrus red mite, Panonychus citri (McGregor) and the Texas citrus mite, Eutetranychus banksi (McGregor). Advantage<sup>®</sup> (carbosulfan), Baam<sup>®</sup>, Mitac<sup>®</sup> (Amitraz), Micromite<sup>®</sup> (5-(4-Chlorophenyl)-2,3-diphenylthiophene), and MK-936 (avermectin B<sub>1</sub>) provided effective control of the citrus rust mite while Amitraz and Avermectin gave effective control of the two spider mite species.

## R21.2. Practical, integrated systems for characterising the performance of soil-applied insecticide granules.

9

A.R. THOMPSON

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Evaluation trials must provide, with minimal effort, maximum information on the 'efficiency' of insecticides in decreasing attacking pest populations, their 'effectiveness' in determining crop yield and 'side effects', including phytotoxicity, effects on beneficial predators and aspects of pesticide residue uptake and persistence. Systems using single-row plots have been developed to evaluate these aspects of insecticides applied to protect vegetables against root- and foliage-feeding pests.

The experiment designs comprise systematic grids of 'check' plots, insecticide treatments being assigned to plots within these grids. Belt delivery attachments are used to apply precisely-known amounts of granules to field-sown or transplanted row crops more accurately and easily than hitherto. Continuous, exponentially-changing doses permit dose/responses to be explored readily. Records are collected with hand-held data-loggers that off-load directly into a computer to analyse the data, tabulate and graph the results.

**R21.2.** INACTIVATION OF MYZUS PERSICAE BY SEVERAL CARBAMATES AND  
**10** ORGANOPHOSPHATES ALONE AND IN MIXTURE WITH A PYRETHROID

CHRISTOPH ERDELEN

Bayer AG, PF-A/Biologische Forschung, D-5090 Leverkusen/FRG

Synchronized larvae (L<sub>3-4</sub>) of apterous *Myzus persicae* on young cabbage leaves were used to determine under laboratory conditions the period required for inactivation by several aphicides alone and in mixture with a pyrethroid with respect to the inhibition of virus transmission by increasing the speed of insecticidal activity.

It was shown that soil application of carbamate granules resulted in a comparably slow insecticidal activity with a tendency towards recovery of formerly inactivated aphids when transferred to untreated plants. Foliar application of conventional aphicides still required several hours to obtain sufficient inactivation of aphids. Treatment with a pyrethroid alone showed very fast action but also a strong tendency towards aphid recovery on untreated plants whereas mixtures of certain organophosphorous compounds with a pyrethroid resulted in both fast and irreversible inactivation of aphids.

**R21.2.** EVALUATING MICROINJECTION FOR CONTROLLING BRONZE BIRCH BORER,  
**11** AGRILUS ANXIUS GORY

NIELSEN, DAVID G., Department of Entomology, Ohio Agricultural Research and Development Center, The Ohio State University, Wooster, OH 44691

Bronze birch borer, Agrilus anxius Gory, attacks and kills white-barked birches, Betula spp., in nurseries and landscapes throughout much of North America. Trees may die within 1 or 2 years following top dieback, the first symptom of beetle establishment. Mauget microinjection has been evaluated in 1982 and 1983 for killing established larvae and preventing infestation. Spring injection to kill overwintering larvae was ineffective. Injection soon after first egg deposition was successful if the tree was vigorous. Later injection was somewhat effective. Since tree vigor apparently influences treatment effectiveness, the practitioner must use good judgement before implementing this control tactic. Betula alba pendula and Betula platyphylla japonica used in our tests in 1983 did not close the injection wound by early September when trees were harvested to evaluate treatment effectiveness.

**R21.2.** HORTICULTURAL OIL FOR PEST CONTROL IN URBAN FORESTRY-EFFICACY AND  
**12** PHYTOTOXICITY STUDIES

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A paraffinic oil refined by the Sun Oil and Marketing Co. is the newest and has been the most available horticultural spray oil in the USA during the past decade. Designated as a 412 oil, (distillation temperature 412 F. at 10 mm Hg.) it differs from all others primarily by the distillation temperature.

Studies during the past 5 years have resulted in some additional phytosafety parameters and additional efficacies. Tests were conducted on a wide range of shrubs, trees and annual flowering plants. Plants exhibiting moisture deficit are most likely to develop phytotoxic symptoms. The 412 oil is an effective insecticide against several species of mites, aphids, scale insects, certain lepidopterous pests and as a feeding deterrent against certain adult stylet-bearing viroliferous insects. When certain organophosphorous insecticides are added to spray oil efficacy is enhanced, and extended because oil acts as a spreader on both foliage and bark. Insect eggs covered with filamentous wax or with hairs and scales are unaffected by oil sprays.

**R21.2.** Interaction of four systemic insecticides for the control of the  
**13** sorghum shootfly, Atherigona soccata Rond. on five varieties of sorghum

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Five varieties of sorghum, were sown at Suwan Farm, Nakornrajasima Province, Thailand. Four systemic insecticides were applied as seed furrow at the rate of 1.00 kg/ha. Observations were made for the number of eggs deposition and sorghum dead heart counts at 14, 21 and 28 days after sowing. For the first, readings of eggs count shows that there is no significant difference among varieties but for insecticides, Birlane gives the satisfactory control, followed by carbofuran, Temik and Dyformate; for the dead heart counts, there are no difference among varieties and insecticides. For the second, readings of eggs counts show that there are no difference among varieties and insecticides, for the dead heart counts, KU 402 shows the significant difference followed by KU 257, DA 80, KU 417 and Late Hegari respectively. For the third, readings of eggs counts show that there is significant difference among varieties, KU 402 gives good control followed by DA 80, KU 257 and late Hegari respectively. For insecticides, Temik gives the best result followed by Dyformate, Birlane and Furadan respectively. While the percentage of dead heart counts appears that there is significant difference among varieties, KU 402 gives the good control followed by KU 257, DA 80, KU 417 and Late Hegari. For insedticides, Temik gives the best result followed by Furadan, Dyformate and Birlane respectively.



**R21.2.** FIELD TESTS TO CONTROL THE LEAFHOPPER EMPOASCA KRAMERI, ROSS  
**14** & MORE IN BEAN (PHASEOLUS VULGARIS L.).

Carlos Murguido

During the period from 1977 to 1982 studies were made of the leafhopper Empoasca krameri Ross & More which is the main pest of bean in Cuba. The dependence of the pest from plant phenology and from temperature was demonstrated by studies of population dynamics. The insect appeared on the crop 4-11 days after seed germination and increased in number until the flowering and pod formation stage (38-45 days), depending on the seeding date and the cultivar. Temperatures of correlation varied from 0.960 to 0.960 and from 0.517 to 0.683, respectively, for 10 different seeding dates. For pest control, different periods of protection, pest infestation indices, and rates of insecticides were assayed. Metamidophos 600 CS at rate of 0.4 l/ha monocrotophos 40 CS at 0.4 l/ha, and dimethoate 38 CS at 0.38 l/ha applied during the critical period of pest infestation when the leafhopper index was about 0.5-1.5/net sweep, according to the plant stage of development, proved to be efficient and economical.

**R21.2.** Compared Effectivity of Various Bacillus thuringiensis Berliner Preparations to Control Heliothis virescens (F.) on Tobacco Grown under Cover.  
**15**

Jesus Jimenes; Y. Karabach and Rosa Fernandez

Research Institute of Plant Protection, Playa, Havana, Cuba

The use of microbiological insecticides to control insect pests has become in many countries a highly efficient phytosanitary practice and a warranty to achieve high yields free of chemical residues, thus reducing the risks born from the almost total dependence on chemical insecticides for the plants, the beneficial insects and man himself.

The effectivity of three commercial Bacillus thuringiensis preparations applied at different rates both alone and combined with low rates of chemical insecticides to control lepidopterous larvae on tobacco grown under cheese-cloth cover was studied at the Tobacco Station "La Sabana".

The results show that the biopreparation Bitoxibacilin at rates of 4 kg/ha and 3 kg + 0,48 kg/ha endosulfan gave an 88,4 % and 89,8 % control, respectively. Similar results were obtained with the chemical insecticide endosulfan at 2,4 kg/ha used as chemical standard which gave an 87,3 % control of lepidopterous larvae; no significant differences were observed between these treatments. Dendrobacilin was found effective at a rate of 3 kg/ha; it gave a 71 % control. Dipel mixed with a low rate of endosulfan and applied at 1 kg + 0,48 kg/ha gave a 65 % control.

## 21.1. 1 AVERMECTINS: THEIR CHEMISTRY AND PESTICIDAL ACTIVITIES

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The avermectins, a novel class of compounds isolated from fermentation of the soil organism Streptomyces avermitilis, consist of eight major components with potent anthelmintic and insecticidal activities. These natural products are described as pentacyclic lactones containing an  $\alpha$ -L-oleandrosyl- $\alpha$ -oleandrosyl dissacharide attached to the macrocyclic lactone ring through the allylic C<sub>13</sub>-hydroxy group. The structure and stereochemistry of the avermectins were determined by spectroscopy, chemical degradation, and x-ray crystallography. A series of derivatives were prepared for biological evaluation through selective reactions of the natural products. A synthetic derivative 13-deoxy-22,23-dihydroavermectin B<sub>1b</sub> aglycon proved identical to the microbial metabolite milbemycin B41D. Avermectin B<sub>1</sub> (MK-936), the key component of the mixture, has demonstrated high potency in laboratory and field evaluations against agricultural and household insect pests in several Orders and phytophagous mites. The chemistry and pesticidal activities of the avermectins will be presented.

## 21.1. 2 BENZOPHENONE HYDRAZONES - A NOVEL CLASS OF BROAD SPECTRUM INSECTICIDES

D.P. GILES AND R.J. WILLIS

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Saffron Walden, Essex, CB10 1UD.

The benzophenone hydrazones are characterised by a high level and broad spectrum of insecticidal activity. They have been shown to be particularly effective against caterpillars and beetles having LD<sub>50</sub> values against the important noctuids *Heliothis armigera* and *Spodoptera littoralis* of about 5 ppm. In addition ants, cockroaches, locusts, termites and flies are extremely susceptible. Many compounds from the series show good effects against animal ectoparasites particularly *Lucilia sericata* and *Boophilus microplus*. This activity is often coupled with animal systemicity.

**S21.1.** DEVELOPMENT OF CME 134 FOR THE CONTROL OF MAJOR PESTS ON  
**3** APPLES, PEARS AND GRAPES

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CELAMERCK GmbH & Co. KG, 6507 Ingelheim / FRG

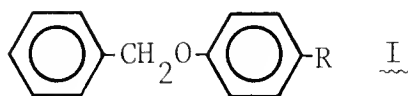
Results from trials carried out with CME 134, a new benzoyl urea compound with low mammalian toxicity, for the control of codling moth, green bud moth, pear psylla, summer fruit tortrix moth, and winter moth will be presented as well as this new insect growth regulator's performance in controlling willow beauty and grape berry moth species in grapes. Good insecticidal activity comparable to that of standard insecticides combined with selectivity leaving beneficials unharmed, make this new compound a promising remedy also fitting into IPM programmes.

**S21.1.** NONTERPENOID INSECT JUVENILE HORMONE MIMICS DERIVED FROM  
**4** 4-(BENZYLOXY)BENZENE

ALBERT B. DeMILO

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Insect juvenile hormone (JH) mimics that are completely nonterpenoid in structure offer distinct advantages over JH mimics that are terpene derived. For this and other reasons, there has been over the last decade a sizable effort by several investigators to develop efficacious nonterpenoid materials capable of eliciting morphogenetic effects in insects similar to those elicited by "classical" terpenoid JH mimics. This talk will describe the JH-mimicking properties, structure-activity relationships, and chemistry associated with a wide variety of nonterpenoid compounds derived from 4-(benzyloxy)benzene, I. Bioassay data was developed from in-vivo morphogenetic tests with Oncopeltus fasciatus, Tenebrio molitor, and Spodoptera frugiperda.



**S21.1.**  
**5**

FIELD EXPERIENCES WITH SN 72129,  
A NEW SELECTIVE INSECTICIDE

EDWARD P. PIETERS, JAMES E. STEFFEL AND TERRY W. MAYBERRY  
NOR-AM Chemical Co., 3509 Silverside Rd., P.O. Box 7495, Wilmington, DE 19803

SN 72129, 3-(2-chlorophenyl)-2-(2,3-dihydro-4-phenylthiazol-2-ylidene)-3-oxopropionitrile, is an experimental insecticide being developed by Schering, AG and its USA subsidiary, NOR-AM Chemical Company. The compound represents a new class of insecticides. SN 72129 is highly efficacious against the Colorado potato beetle, Leptinotarsa decimlineata, particularly those that are resistant to synthetic pyrethroids. It is also active against the pear psylla, Psylla pyricola, but is relatively low in toxicity to common predators and parasites of the Colorado potato beetle and pear psylla. The primary mode of action of SN 72129 is by ingestion. Preliminary tests show very low mammalian and fish toxicity. SN 72129 is non-systemic and non-toxic to crops so far tested.

**S21.1.**  
**6** INSECTICIDAL AND IGR EFFECTS OF THIOSEMICARBAZONES AND  
RELATED STRUCTURES

L.-E. K. PEDERSEN  
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A number of 2-acetylpyridine thiosemicarbazones and 1,4-diphenyl semicarbazide derivatives and related structures have proved insecticidal. The effects of these compounds are inhibition or delay of the moulting process and erratic moulting in Dysdercus cingulatus, Locusta migratoria, Aedes aegypti, and other insect species. Some of the compounds cause morphological abnormalities in larvae of Drosophila melanogaster. In addition the behaviour is significantly affected after treatment with some of these compounds.

The observed effects are discussed in relation to known IGR's and the antibiotic Kasugamycin.

S21.1.  
7

## A REVIEW OF PROGRESS ON THE NEW ACARICIDE, CLOFENTEZINE

R.W. LEMON AND D.J. PEREGRINE

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This paper deals with laboratory findings, field trials and first commercial useage of the new specific acaricide, 3,6-bis(2-chlorophenyl)-1,2,4,5-tetrazine. The unique activity of this compound as an ovicide against the overwintering eggs of the European Red mite Panonychus ulmi is described, as well as its safety to beneficial species of insects and mites. The integration of sprays of the compound in programmes involving the use of the predatory mite Typhlodromus pyri on apples is dealt with.

S21.1.  
8

## CONTROL OF PESTS OF OIL SEED RAPE WITH FASTAC (WL85871)

J P FISHER, S W SHIRES, SHELL RESEARCH LIMITED, SITTINGBOURNE RESEARCH CENTRE, KENT, AND PH DEBRAY, AGRISHELL S.A., LYONS, FRANCE.

Field trials over several seasons in oil seed rape have shown that FASTAC will control the major pests in this crop at rates of 5-20 g/ha A.I.

Since chemical control is frequently complicated by the simultaneous presence of both pests (especially Meligethes, Ceutorrhynchus and Dasyneura) and large numbers of bees, a deliberate application of 20 g/ha A.I. was made by helicopter to a crop in full flower during peak foraging activity. After a decline, foraging of the bees returned to normal the next day. Careful monitoring of beehives did not show either significant mortality or detectable effects on brood development and hive condition at the end of the season.

Current recommendations for insecticides stress the need to avoid spraying crops which are fully or even partially in flower to avoid killing bees. The results of our investigation indicate that this restriction need not be applied to FASTAC so that sprays can be timed to coincide with peak pest invasions and so offer maximum benefit.

S21.1.  
9

# INSECTICIDAL PROPERTIES OF OK-135, A NEW CARBAMATE INSECTICIDE.

Osaki,N., Kiminami,T., Murai,K., Haruyama,H., Aoki,Y. and Umetsu,N. (Pestic. & Biol. Sci. Research Lab., Otsuka Chemical Co., Naruto, Tokushima-ken 772 JAPAN

OK-135, S-methyl N-[N-[N-benzyl-N-(ethoxycarbonylethyl)aminothio]-N-methyl-carbamoyloxy]thioacetimidate, is a new oxime carbamate insecticide which is currently undergoing development and is being widely tested. It is a new type of sulfenylated derivative of methomyl and has produced outstanding control of many important Lepidoptera, and some Hemiptera and Coleoptera that attack economically important agricultural crops. The major features of this insecticide include : favourable mammalian toxicity ; outstanding residual effectiveness to many pests, especially when applied to cotton foliage ; absence of phytotoxicity toward cotton and other crops ; and good systemic insecticidal activity against Lepidopterous larvae. OK-135 is particularly effective as a stomach poison insecticide and also has contact toxicity. No or very low In Vitro antiacetylcholinesterase activity was observed in housefly head preparation.

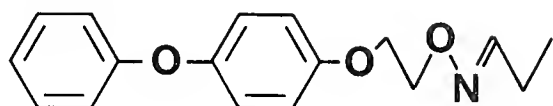
S21.1.  
10

# OXIME ETHER COMPOUNDS AS A JUVENILE HORMONE LIKE ACTIVITY.

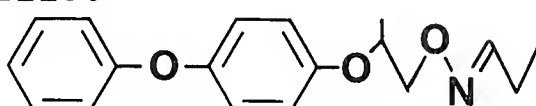
HATAKOSHI,M., OHSUMI,T., KISHIDA,H., ITAYA,S., NAKAYAMA,I. AND FUJITA,Y. (Sumitomo Chem. Co., Ltd., Takarazuka, Hyogo, 665 Japan)

S-21149 and 21150, new synthetic compounds, have a high juvenile hormone like activity and were found to prevent the adult emergence of *Culex pipiens* and *Musca domestica* when they were treated at larval stage. The IC<sub>50</sub> values (ppb) of S-21149 and 21150 against last instar larvae of *C. pipiens* were 0.000036 and 0.00034. S-21149 showed a high activity against third instar larvae of *C. pipiens* even in a brief immersion. S-21149 and 21150 showed 10-fold activity against 4-day-old larvae of *M. domestica* compared to methoprene. Both compounds showed high activity against *Trialeurodes vaporariorum*, *Lasioderma serricorne*, *Unaspis yanonensis*, *Blattella germanica* and other insects.

S-21149



S-21150



**S21.2.** WHICH INSECT PESTS CAN BE CONTROLLED BY APPLICATION OF  
**1** NEEM (AZADIRACHTA INDICA) SEED EXTRACTS?

H. SCHMUTTERER

Institut für Phytopathologie und Angew. Zoologie, Giessen

Neem seed extracts are recognized as promising natural pesticides, especially for developing countries where considerable amounts of seeds are available.

Simple aqueous extracts, preparable by farmers themselves, show a high degree of efficacy whereas effective enriched extracts can be produced in small scale/cottage industries.

The active principles of the extracts, such as azadirachtin and some other tetranortriterpenoids, act as antifeedants and/or growth regulators leading to high mortality during moults and considerably reduced fecundity.

Lepidoptera of various families (Noctuidae, Pyralidae, Pieridae, Plutellidae, Arctiidae) proved to be sensitive in laboratory and field experiments in temperate and tropical climates.

Freely feeding larvae of some Coleoptera (*Epilachna* spp. etc.) are also easy to control in the field. Other sensitive target species are grasshoppers and locusts (*Schistocerca*, *Zonocerus*), hemipterous and homopterous insects. Various leaf- and plant-hoppers (*Nilaparvata*, *Empoasca* etc.) show a clear reaction to neem seed extracts, whereas the control of aphids is quite difficult. Dipterous and hymenopterous insects vary considerably regarding their sensitivity.

**S21.2.** Development of a standardized and formulated insecticide  
**2** from a crude neem kernel extract

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Biologically very active components from neem (*Azadirachta indica*) kernels have been tested in many countries in the laboratory. For practical use, especially for application on a large scale in the field it is necessary to standardize and formulate the extracts.

By selection of particular solvents and a few steps of purification the most active compounds can be enriched and standardized. This is confirmed by TLC and bioassays. With regard to field application of neem extracts as sprays it is important to know the physiocochemical properties of the enriched material. The active compounds cannot be obtained in liquid form but are soluble in lower alcohols and some other polar solvents. On the other hand, they are not or only slightly soluble in water, ether and unpolar solvents. Therefore it is necessary to formulate the extracts with surface-active agents and special solvents.

It is feasible to produce wettable powders (WP), emulsifiable concentrates (EC) and ULV-formulations. The effectivity of various EC's with different solvents, adjuvants and emulsifiers were confirmed by field and laboratory tests.

21.2. Synergistic properties of piperonyl butoxide when combined  
3 with different neem seed extracts in laboratory- and field trials.

W. Lange, Giessen

Institut für Phytopathologie u. Angewandte Zoologie

The synergist piperonyl butoxide has the potential to increase significantly the effect of three different neem seed kernel extracts in fourth instar larvae of Plutella xylostella. An increase of effectiveness of the extracts was also obtained in larvae of Leptinotarsa decemlineata, Epilachna varivestis and Pieris brassicae.

Synergism was expressed not only by increase of mortality but also by acceleration of the onset of mortality when young instar larvae were used.

In field trials the synergistic properties of piperonyl butoxide were tested with larvae of L. decemlineata, P. brassicae and P. xylostella. Under these conditions the synergist did not cause a higher mortality but a reduction of  $LT_{50}$ .

521.2. NEEM SEED EXTRACT AND AGROMYZID LEAFMINERS  
4

HIRAM G. LAREW<sup>1</sup>, RALPH E. WEBB<sup>2</sup>, and DAVID J. WARTHEN, JR.<sup>3</sup>

<sup>1,2</sup>Florist and Nursery Crops Laboratory, USDA, ARS, Beltsville, MD 20705, USA

<sup>3</sup>Biologically Active Natural Products Laboratory, USDA, Beltsville, MD 20705

A crude ethanol extract of seeds from the neem tree (Azadirachta indica A. Juss) was tested as a systemic insecticide against Liriomyza sativae Blanchard and Liriomyza trifolii (Burgess). Used as a soil drench at a range of concentrations, neem extract had larvicidal activity with high carryover activity against the puparial stage of L. sativae in both 'Rutgers' tomatoes and 'Henderson Bush' beans. Neem also showed promising insecticidal properties when it was used as a systemic in 'Iceberg' Chrysanthemum cuttings to protect against L. trifolii.



**S21.2.** GROWTH-DISRUPTING EFFECTS OF AZADIRACHTIN ON THE LARVAE  
**5** OF THE ASIATIC CORN BORER (OSTRINIA FURNACALIS GUENÉE)

CHIU SHIN-FOON   ZHANG XING   LIU SIU-KING   HUANG DUAN-PING  
Laboratory of Insect Toxicology, South-China Agricultural College, Guangzhou, China

A series of experiments were conducted on the growth-disruption effects of azadirachtin on the larvae of the Asiatic corn borer, (Ostrinia furnacalis Guenée). The 3<sup>th</sup> or 4<sup>th</sup> instar larvae were fed with the artificial diet containing 20 ppm azadirachtin for two days, then transferred to normal diet for physiological or histological examinations. The treated larvae shrank, the body weight decreased gradually, and the lipid content was less than that of the control. The brain, corpus cardiacum, corpora allata and the prothoracic gland of the larvae in 15 - 20 days after treatment all showed histopathological changes. The titer of 20-hydroxyecdysone of the treated larvae was significantly lower than that of the control at the time of pupation as examined by the method of radioimmunoassay. The black thoracic legs and brown thoracic spots appeared on the treated larvae and the results of examination by light and electron microscopes showed that the necrosis occurred in the epidermis of the black thoracic leg and the thoracic epidermis became invisible. All these pathological alterations of the larval organs and tissues indicate that azadirachtin profoundly affects the insect, perhaps by acting on the neuro-endocrine system.

**S21.2.** DEVELOPMENTAL DEFECTS INDUCED BY AZADIRACHTIN IN THE TOBACCO  
**6** HORNWORM, MANDUCA SEXTA.

S.E. REYNOLDS, M.M.A. BRISTOW and F.M. JUDSON  
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Claverton Down, Bath, BA2 7AY, UK.

Azadirachtin acts as an IGR in Manduca larvae, causing death or developmental defects at the ecdysis following treatment. To separate the effects of azadirachtin on development from those on feeding, we treated final instar larvae which had ceased to feed prior to pupation. At high doses (1 µg/g), azadirachtin caused death because the treated insects failed to moult. Apolysis, cuticle deposition and tanning all occurred, but the cuticle was not shed. At lower doses (0.1-0.5 µg/g) moulting was delayed in a dose-dependent fashion. Ecdysis was attempted but in most cases failed and the insects died. At still lower doses (0.02-0.05 µg/g), azadirachtin did not kill the insects but caused specific morphological defects in the resulting pupae. The nature of these defects indicates that azadirachtin may act by interfering with the action of ecdysteroid hormones.

## 521.2. IGR ACTIVITY OF AZADIRACHTIN DERIVATIVES IN THE EPILACHNA 7 VARIVESTIS BIOASSAY

CH.CZOPPELT, H.FORSTER and H.REMBOLD

Max-Planck-Institute for Biochemistry, D-8033 Martinsried, FRG

Azadirachtin is composed of two main (azadirachtin A and B) and two minor (azadirachtin C and D) components which are a mixture of stereoisomers. By hydrolysis and methanolysis, some isomers and derivatives were found to be derived from azadirachtin A and B, respectively. All the four main components are highly active as insect growth regulators (IGR) in the E. varivestis bioassay. No feeding inhibition and no acute toxicity was found. The last instar larvae failed to pupate and finally died after an extended larval period. Postembryonic development of E. varivestis is delayed by several days as compared with the control. The growth regulating effects on E. varivestis larvae are discussed as an interference of the azadirachtin derivatives with the insect endocrine system.

## 521.2. INSECT FEEDING DETERRENTS FROM MELIACEAE 8

W.KRAUS, W.GRIMMINGER, R.CRAMER, M.SCHWINGER, E.KEIL, K.KYPKE

Dept.of Chemistry, University of Hohenheim, D-7000 Stuttgart

Extracts of several melia plants such as Azadirachta indica, Melia azedarach, Toona ciliata, and Toona sureni show strong insect antifeedant activity. From these extracts we have isolated a series of novel biologically active tetranortriterpenoids and pentanortriterpenoids. The biological tests of these compounds will be reported. Structure-activity relationships will also be discussed.

**521.2.** THE BIOLOGICAL ACTIVITY AGAINST INSECTS OF SOME COMPONENTS  
**9** FROM MELIACEAE

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Dept. of Chemistry, University of Hohenheim, D-7000 Stuttgart

In order to obtain definite, comparable, and reproducible results when testing the insect feeding deterrent and growth disrupting effect of different substances, experiments were carried out with several pure components from Meliaceae on the following problems:

- 1) Application of the substance to be tested
- 2) Influence of the arrangement and the duration of the bioassay on the result
- 3) Documentation and evaluation of the biological activity

**521.2.** THE EFFECT OF SOME PLANT EXTRACTS ON INSECT PESTS OF COMMON  
**10** BEANS (Phaseolus vulgaris L.).

A.K.Karel and H. Hongo

University of Dar es salaam, Box 3005, Chuo Kikuu, Morogoro, Tanzania

The effect of crude extracts from neem (Azadirachta indica A.Juss) kernels, neem leaves, tomato (Lycopersicum esculentum) leaves and hot pepper (Capsicum annum) was investigated under field conditions against the foliar beetle (Ootheca bennigseni Weiss), flower thrips (Taeniothrips sjostedti Tryon) and pod borer larvae (Maruca testulalis Geyer and Heliothis armigera Hb. on common beans. The effect of plant extracts on insect pests and plant damage was compared with those of a commercial insecticide.

The aqueous extracts from neem kernels and hot pepper fruits caused repellent effects in foliar beetles and flower thrips. However, the repellent effects did not last long. Neem kernel extract had some antifeedant effects in the larvae of the two pod borers. Plots treated with neem kernel and hot pepper fruit extracts were relatively less damaged and had a significantly lower incidence of insect pests.

Preliminary results indicate that both neem kernel and hot pepper fruit extracts have potentials in giving good protection of beans from insect pests; they are indigenous, safe and readily available to farmers in Tanzania.

## 521.2. PRELIMINARY REPORT ON THE PREVENTION & DESTRUCTION

### 11 OF WHITE ANTS BY PLANT PESTICIDES

LEI ER-CHANG (author )

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Up to the present, pesticides which are widely used both at home and abroad in killing white ants are largely such chemical compounds as  $AS_2O_3$ , Chlordane, DDT, etc. Although these chemicals have helped human beings to promote their ability and power to destroy white ants, yet they have made the previously healthy environment seriously contaminated, and, what is more, they are not only harmful to the health of men and livestock, but dangerous to their lives as well. For the purpose of getting rid of these commonly suffered disasters, both our country and other countries are devoting themselves to the development of such pesticides as have to be the most effective but less poisonous or less poison-remaining when they are employed in checking the attack of white ants.

In view of these unfavourable conditions mentioned above, we selected some medicinally used plants and *Coptis* *Formosensis* *Shoraki* as samples, putting them into test so as to search for a new way to destroy white ants by using plant pesticides instead of those chemicals. This preliminary report is a part of our research work at this subject. It consists of the following descriptions, namely, (1) how we found, through careful selection and repeated tests, that inside the fruit of *Brucea Javanica* (L.) Merrin there are some components which have proved to be more desirable and effective in killing white ants, and that Br-uceine A.B.C.D.E.F.G. etc. showed better effect in killing white ants without any harm done to men and livestock. (2) how we extracted this useful components from *Brucea* and separated the former from the latter. (3) the measurement of poison capabilities of the plant pesticides while they were being tested on the spot; the observation of the symptoms shown by the white ants when they died from being poisoned by the plant pesticides, and (4) summary and discussions.

## 521.2. LABORATORY EVALUATION OF THE EXTRACTS OF SEVERAL MEDICINAL PLANTS

### 12 AGAINST CYDIA POMONELLA (L.) AND PIERIS BRASSICAE L.

C. ABIVARDI and G. BENZ

Department of Entomology, Swiss Federal Institute of Technology, Zurich, Switzerland

Extracts of the outer fleshy parts of the fruits of *Juglans regia*, the bulbs of *Allium cepa*, the foliage of *Artemisia absinthium*, *Equisetum arvense*, and *Marrubium vulgare*, the fruits of *Rosa canina* and the flowers of *Lavendula vera*, and *Matricaria chamomilla* were tested for feeding toxicity and antifeedant as well as oviposition deterrent activity against *Cydia pomonella* and *Pieris brassicae* at 25°C and 60% RH. The extracts of *J. regia*, *E. arvense*, and *R. canina* inhibited the development of *C. pomonella* to different degrees, when they were incorporated into the diet at a rate of 1% (V/V or W/V). In addition to the toxic action the extract of *J. regia* had also a definite antifeedant effect. Similar effects, i.e. reduced feeding rates of the 3rd stage larvae of *P. brassicae* were observed on cabbage leaves (*Brassica oleracea* var. *capitata*) treated with a 2% water-solution of the extracts of *A. absinthium*, *E. arvense*, *M. chamomilla*, and *J. regia*. Oviposition of *C. pomonella* on the inner surface of plastic beakers, treated with the extracts of *J. regia*, *M. vulgare* or *A. absinthium*, was inhibited to different degrees.

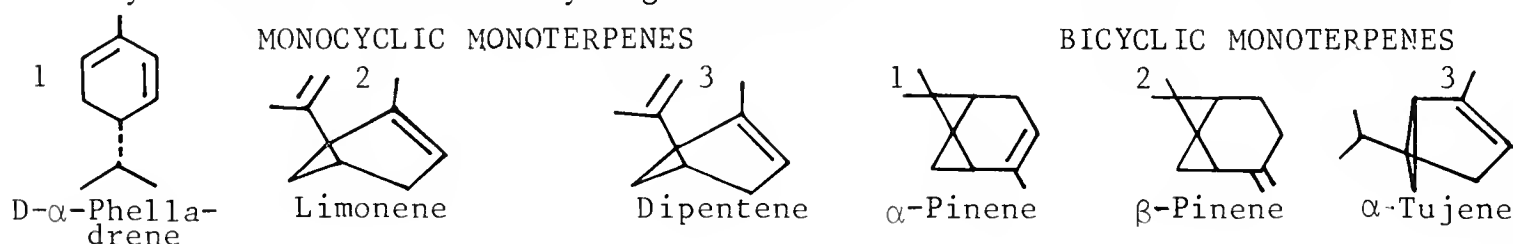
**S21.2. 13** ANTIFEEDANT ACTIVITY OF THE ESSENTIAL OIL FROM THE GUM OLEORESIN  
BOSWELLIA SERRATA (FAM. BURSERACEAE) AGAINST TOBACCO CATERPILLAR,  
SPODOPTERA LITURA. F

D. RAGHUNATHA RAO, THAKUR, S. SINGH, B.H. KRISHNAMURTHY RAO, B. KISHEN RAO,  
T.J. DENNIS<sup>1</sup> AND G. SRIMANNARAYANA<sup>2</sup>

Entomology Section, Department of Zoology, Chemistry<sup>1,2</sup>, Osmania University,  
Hyderabad 500007, India

The essential oil from the gum oleoresin of *Boswellia serrata* which has 3 monocyclic monoterpenes (D- $\alpha$ -Phellandrene, Limonene and Dipentene) and 3 bicyclic monoterpenes ( $\alpha$ -Pinene,  $\beta$ -Pinene and  $\alpha$ -Tujene) showed positive antifeedant activity of various concentrations of 5, 4, 2, 1 and 0.5% made in acetone against fourth instar larvae of tobacco caterpillar, *Spodoptera litura* F. The parameters chosen for the calculation of antifeedant activity were: (a) percentage area of protected leaf, (b) percentage weight of protected leaf, and (c) percentage starvation. The percentage starvation and leaf-area was worked out according to Ascher and Sarah Nissim (1965).

The data regarding the percentage of protected leaf area (92.78 to 29.09, against 9.5 in control), protected leaf weight (58.36 to 20.55, against 13.09 in control), and starvation (77.08 to 35.4%, against 0% in control) showed dose dependant activity. The phagodeterrent activity was evaluated quantitatively from the above data by regression method.



**S21.2. 14** MONITORING THE PRESENCE OF THE ANTIFEEDANT WITHANOLIDE E IN *WITHANIA*  
*SOMNIFERA* WITH A *SPODOPTERA* ASSAY AS COMPARED TO TLC

K.R.S. ASCHER<sup>1</sup>, M. ELIYAHU<sup>1</sup>, E. GLOTTER<sup>2</sup>, E. KIRSON<sup>2</sup> and A. ABRAHAM<sup>2</sup>

<sup>1</sup>Volcani Center, Bet Dagan, and <sup>2</sup>Faculty of Agriculture, Rehovot, Israel

The geographical distribution of the chemotypes of *Withania somnifera* Dun. (Solanaceae) in Israel was re-investigated. In the distribution area of chemotype II (major steroidal constituent, withanolide D), plants of chemotype III (major steroidal constituent, withanolide E) were also found. The antifeedant properties for *Spodoptera littoralis* larvae of leaves of *W. somnifera* populations belonging to chemotype III are due to the presence of withanolide E and may be used, as confirmed by chemical analysis, to differentiate between chemotype III and other chemotypes of *W. somnifera*.

S21.2.  
15

## LIGHT-ACTIVATED INSECTICIDES FROM PLANTS

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A new class of naturally-occurring compounds found in many plant families is currently being investigated for its action against phytophagous insects and aquatic forms such as mosquito and black fly larvae. These compounds are activated by light, particularly the near UV end of the spectrum.

In this presentation we examine photosensitization by secondary plant metabolites including furanocoumarins, polyacetylenes and the isoquinoline alkaloid berberine. We provide evidence of the toxic effects of  $\alpha$ -terthienyl, a thiophene derivative, to the polyphagous Euxoa messoria and to aquatic larvae, of the polyacetylene phenylheptatriene to E. messoria and of berberine to the mosquito Aedes atropalpus. The mode of action of these compounds is also discussed.

## S21.2. OCCURENCE OF INSECTICIDAL SUBSTANCES IN NATIVE AND INTRO- 16 DUCED PLANTS OF CENTRAL EUROPE

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H.J. BESTMANN & OTTO VOSTROWSKY - Institute of Organic Chemistry University Erlangen-Nürnberg, D-8520 Erlangen, Fed.Rep.Germany

Water, methanol, and ethanol extracts from more than 150 plant species from different families were tested for insecticidal and repellent activities. Special attention was given to plants containing essential oils. The volatile plant substances were examined directly by placing the insects together with fresh plant material or by exposing them to steam distillation extracts.

About 10-50% of the extracts - according to the solvent used - were shown to have insecticidal properties, 10-15% of these with strong effects resulting in high mortalities of the insects tested. Also the volatile substances of numerous plants were proven to be effective against aphids and other test insects. It was interesting to note that the extracts often showed a selective efficacy against different target insects.

**S21.2.** INSECTICIDAL ACTIVITY OF THE EXTRACT OF SEVEN PLANT SPEC-  
**17** IES AGAINST Spodoptera littoralis (Boisd.) and Tribolium confusum (DUF.)

MOHAMED A.KANDIL; HOSNI, S.M.FAHMY; AHMED A.BARAKAT and MAKRAM A.SAYED AHMED.- ECONOMIC ENTOMOLOGY AND PESTICIDES DEP. FACULTY OF AGRICULTURE, CAIRO UNIVERSITY, GIZA, EGYPT .

The insecticidal activity of seven plant extracts was studied with insects. The order of efficiency of the plant extracts against 2nd. instar larvae of the cotton leafworm was Devil's apple, Caraway, Bead tree, Downythorn apple, Warm wood, Santonica and Budding grass. The Downythorn apple extract was the most effective against the 4th instar. All tested plant extracts exhibited ovicidal action against S.littoralis eggs except that of Budding grass. Only three plant extracts namely, Budding grass, Warm wood and Santonica exerted positive antifeeding effect. Devil's apple and caraway extracts exhibited highly toxic action against T.confusum. Moreover fumes evolving from Caraway extracts residues have a toxic action to the adult of T.confusum .

**S21.2.** FEEDING DETERRENTS OF *COSTELYTRA ZEALANDICA* AND PLANT RESISTANCE  
**18**

G.B. RUSSELL, G.A. LANE, D.R. BIGGS and O.R.W. SUTHERLAND

The subterranean, root feeding larvae of *Costelytra zealandica* (Coleoptera: Scarabaeidae) cause major damage on New Zealand pastures. A study of several resistant legumes has shown that the larvae are deterred from feeding by the isoflavonoid constituents of the roots. The most active compounds are those that have also been recognised as phytoalexins in the foliage of legumes. The feeding deterrent activity of these compounds is highly structure dependent and relates to their stereochemistry.

Besides isoflavonoids, the resistant plant, *Lotus pedunculatus* contains high yields of glucose nitropropionic acid esters which are feeding deterrent and toxic at the concentrations (0.2% ww) found in the root. The nitro esters do not have a particularly high biological activity but they make a 50% contribution to the total feeding deterrent activity of the plant because of their high concentration. By contrast, the isoflavonoids are very active and account for a significant part of the feeding deterrent activity of the plant in spite of their low yield (ca. 10 ppm). This is an example of quantitative and qualitative resistance and the understanding of such mechanisms will assist the development of an insect resistant plant.

**S21.2.** RESPONSES TO ALLELOCHEMICS IN OLIGOPHAGOUS AND POLYPHAGOUS  
**19** LEPIDOPTEROUS LARVAE: A COMPARATIVE STUDY

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Many allelochemicals are important in influencing the feeding strategies of phytophagous insects. Progress in elucidating the sensory code which mediates their recognition is often hampered by a lack of sufficiently detailed behavioural studies to allow aspects of the sensory message to be associated with elements of the insect's behaviour. We have constructed models which correlate various aspects of feeding behaviour with sensory input and illustrate differences in the mechanisms of discrimination operating in oligophagous and polyphagous insects.

**S21.2.** Interactions of plant allelochemicals and amino acids on the  
**20** development of *Heliothis virescens* F. (Lep.: Noctuidae)

LUTZ KRAFFT, FRED KLINGAUF

Institute for Biological Pest Control, BBA, Heinrichstr. 243,  
D-6100 Darmstadt, Fed. Rep. Germany

Plant allelochemicals (i.e. Nicotin, Quercetin and Gossypol) and single amino acids were incorporated either individually or in combinations into an artificial diet. After feeding these diets to *Heliothis virescens*, growth rates by means of weight and time were determined. The plant allelochemicals well as the amino acids influenced both parameters in a different way. More effect was observed for either weight increase or developmental time. If combinations of both compound groups were offered in the diet, additional effects as well as interactions could be found. Out of the results a model for the relation of nutritional value and insect development was established.



**521.2.** BIOCHEMICAL STUDIES ON THE EFFECT OF CHEMOSTERILANTS OF PLANT ORIGIN  
**21** ON *AEDES AEGYPTI* LARVAE.

S.N.H.NAQVI, Zoology Department, University of Karachi, Karachi. Pakistan.  
H.M.S.SULAIMAN and A.M.S.MUHAMMAD, Biology Department, Mosul University, Iraq.

ABSTRACT

Shikonin, a compound extracted and purified from Alkana hirsutissima and its analog (Afzal and Taufiq 1975) proved to be a sterilant (Sulaiman, *et.al.* 1978) against *Aedes aegypti* L. Effect of these compounds was studied on diphenoloxidase, alkaline phosphatase and cholinesterase, in comparison with tepa and hempa.

Colorimetric determinations indicated that shikonin, shikonin angelate and hempa inhibited the enzyme activity up to 50%. It was confirmed by histochemical zymograms. Tepa was less effective on the activity.

Diphenoloxidase was not inhibited by these compounds except some effect by shikonin. Histochemical pattern also showed clear band in all the gels.

Colinesterase was inhibited by all the compounds from 60% - 90% level. It was confirmed by histochemical zymograms. These experiments indicate that cholinesterase and alkaline phosphatase have some relation with metabolism of these compounds

**521.2.** CHEMICAL STIMULI AFFECTING OVIPOSITION BY CRUCIFER-FEEDING INSECTS  
**22**

J.A.A. RENWICK and CELIA D. RADKE  
Boyce Thompson Institute, Tower Road, Ithaca, NY 14853

Host selection by phytophagous insects is often dependent on assessment of potential sites by ovipositing females. Both physical and chemical factors may be involved in orientation, but the final step of acceptance or rejection is usually chemically mediated. Comparative studies on specialist and generalist insects suggest that the relative importance of deterrents and stimulants is quite different. The cabbage looper, Trichoplusia ni, avoids plants occupied by larvae as a result of volatile and non-volatile chemicals released from the damaged plants. Pieris rapae butterflies oviposit in response to contact stimuli at the leaf surface, but negative cues also play a role in the assessment process. Landing on a plant depends on the absence of repellents or presence of attractants, and oviposition is controlled by a balance between positive and negative inputs from less volatile chemical constituents.

**21.2.** ROLE OF PLANT-DERIVED SESQUITERPENES IN SUPPRESSING ALARM RESPONSE  
**23** IN APHIDS

D.C. GRIFFITHS, G.W. DAWSON, J.A. PICKETT AND CHRISTINE M. WOODCOCK  
ROTHAMSTED EXPERIMENTAL STATION, HARPENDEN, HERTS., AL5 2JQ, U.K.

It is demonstrated that many plants contain (E)- $\beta$ -farnesene which is the alarm pheromone for most aphid species. However, these plants are colonised by aphids, because the effect of (E)- $\beta$ -farnesene is inhibited by (-)- $\beta$ -caryophyllene and, to a lesser extent, certain other sesquiterpenes that are also present. Aphids on these plants respond normally to (E)- $\beta$ -farnesene released by aphids or to the synthetic compound but do not respond if the sesquiterpene inhibitor is applied simultaneously.

**21.2.** REPLACEMENT OF SOYBEAN PROTEIN HYDROLYSATE WITH PURE AMINO ACIDS  
**24** IN THE LARVAL DIET OF THE OLIVE FRUIT FLY.

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The performance of the olive fruit, Dacus oleae (Gmel.) larvae grown in a soybean protein hydrolysate-free diet supplemented with mixtures of amino acids was studied. It was found that certain amino acid mixtures were detrimental to larval growth and development while others gave satisfactory results when compared to the control. Mixtures of essential amino acids alone were not able to support satisfactory pupal yield and the ratio of essential to non-essential amino acids was important for larval growth and development. An amino acid mixture for replacing the soybean protein hydrolysate will be reported and discussed. This work was done in connection with the quality problems of the artificially reared olive fruit flies used in a sterile insect field program.

**S21.2.** MECHANISMS OF SOYBEAN RESISTANCE TO DEFOLIATION BY THE SOYBEAN  
**25** LOOPER, PSEUDOPPLUSIA INCLUDENS WALKER.

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The Asian soybean variety 'Niyako White' (United States Plant Introduction 227687) is resistant to defoliation by larvae of the soybean looper, Pseudoplusia includens Walker (Lepidoptera: Noctuidae). Resistance is greater in mature leaves than in immature leaves of vegetative plants. Artificial wounding of PI 227687 leaves retards growth and increases mortality of P. includens larvae reared on fresh foliage fed to larvae three days after wounding. Growth inhibition of P. includens larvae is affected by feeding deterrence and reduced efficiency of conversion of digested food. Larval mortality is greater and survivor weights lower on artificial diet supplemented with the methanol extract of PI 227687 leaf powder than on diets supplemented with petroleum ether or dichloromethane extracts, or similar extracts of the susceptible cultivar 'Davis'. Larvae reared on PI 227687 methanol extracts also have decreased levels of midgut hydrolytic esterase activity, relative to those reared on similar extracts of Davis. Highly resistant PI 227687 leaves contain 10X more coumestrol, a plant estrogen with antihivore activity and moderate P. includens toxicity; than do low resistance leaves or Davis leaves. Additional fluorescent compounds existing in complex with coumestrol and unrelated water soluble factors unique to PI 227687 leaves may also function in P. includens resistance.

**S21.2.** EFFECTS OF PRECOCENE I AND II ON THE DEVELOPMENT AND  
**26** REPRODUCTION OF HETRACIRS LITTORALIS .

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Precocene I or II (10-100  $\mu$ g/insect) was topically applied to 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> instar nymphs of the grasshoppers Hetracris littoralis. Results with either compounds led to different degree of irreversible precocious metamorphosis at the subsequent molt without the involvement of intercalary instar. However, precocene treated (PI > 60 and PII > 40  $\mu$ g) 3<sup>rd</sup> instar gave rise to some precocious adults at the following molt, whereas other first responded and metamorphosed precociously in the 5<sup>th</sup> instar. The effective dose required of PI (> 60  $\mu$ g) was higher than those of PII (> 30  $\mu$ g). Meanwhile the effective dose of either compounds should be increased with nymphal metamorphosis. Ovarian development of normal looking adult females emerged from pretreated 5<sup>th</sup> instar with PII was found to be inhibited. JH III (20  $\mu$ g/insect) could restore the normal ovarian development to some extent.

P21.-  
1

# DIFFERENT ELECTRON MICROSCOPICAL EFFECTS OF THE CLOSELY RELATED CHITIN SYNTHESIS INHIBITORS NIKKOMYCIN X/Z AND POLYOXIN D.

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Different effects of the closely related chitin synthesis inhibitors Nikkomycin X/Z and Polyoxin D are demonstrated electron microscopically and discussed according to the mechanisms of action. Effects on cuticle deposition during moulting, on reproductive organs, and on the gut histology are compared. Obvious differences in the pattern of defects lead to the suggestion, that although both metabolites are closely related in structure and primarily inhibit a regular cuticle deposition in T.urticae, different targets of their action may exist.

P21.-  
2

# A NEW INSECTICIDAL SUBSTANCE OF PLANT

EIJI TANIGUCHI (Laboratory of Pesticide Chemistry, Faculty of Agriculture, Kyushu University, Fukuoka, Japan 812)

A new insecticidal compound was isolated from a herbaceous plant, *Phryma leptostachya* L.. The structure was elucidated as a novel benzodioxane-sesquilignan on the basis of informations from chemical and instrumental analyses.

The insecticidal activity of the compound was comparable to that of fenitrothion, when WHO SRS houseflies were subjected to a topical application test. The compound was also toxic to silkworms at low doses. The insects showed no hyperconvulsive motions in treatment with the toxin.

**P21.-** EFFECTS OF DIFFERENT NEEM SEED KERNEL EXTRACTS ON  
**3** VARIOUS MOSQUITO SPECIES

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The toxicology data of different neem (Azadirachta indica) seed kernel extracts on Aedes aegypti, Ae. togoi, Culex pipiens quinquefasciatus and Anopheles stephensi are presented.

Furthermore, the late-effects of some extracts on adults emerged from treated larvae, as longevity, fecundity, fertility, follicle and oocyte growth of selected mosquito species are scrutinized.

The results will underline the growth-disrupting character of neem seed components like azadirachtin which interferes with ecdysone balance in larvae and adults of mosquitoes.

**P21.-** INSECTICIDAL/ACARICIDAL ACTIVITY OF FENPROPATHRIN.  
**4**

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Fenpropathrin, a new pyrethroid is effective against many species of insects and mites, infesting fruit and nut crops, vegetables, field crops, ornamentals and house and gardens.

**P21.-** MK-396: INGESTION AND CONTACT TOXICITY AGAINST LEPIDOPTERAN PESTS  
**5** AND POTENTIATION BY OIL AND PIPERONYL BUTOXIDE

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MK-936 (avermectin B<sub>1</sub>), a natural product insecticide produced by Streptomyces avermitilis, displayed greater ingestion toxicity and lesser contact toxicity than the pyrethroid fenvalerate against 2 lepidopteran pests. When larvae were fed treated foliage, MK-936 was more effective than fenvalerate against Heliothis virescens, and was as effective as fenvalerate against Spodoptera eridania. In topical application assays, fenvalerate was considerably more toxic than MK-936 against Spodoptera and Heliothis. Addition of an emulsifiable oil increased the activity of MK-936, while piperonyl butoxide, a proven synergist of pyrethroids, had no effect on MK-936 activity.

**P21.-** CONTROL OF THE AERIAL FORM OF THE GRAPE PHYLLOXERA  
**6**

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The grape phylloxera, Daktulosphaira vitifoliae (Fitch) is an increasingly important pest in eastern North America. This is due in part to susceptibility of American cultivars. However, greatest concern is over new plantings, comprised primarily of French-American hybrids.

Over the past 10 years more than 10 foliar and subsurface candidate insecticides have been screened against the foliar form of the phylloxera. Organophosphates, chlorinated hydrocarbons, carbamates and synthetic pyrethroids were all evaluated for efficacy against the aerial form.

Greatest and most consistent gall reduction over a period of years was obtained with phosalone and endosulfan at the rate of 1.12 kg ai/ha applied as foliar sprays. These materials have given exceptional results over the years when administered in two applications; at bloom and again ten days later. Endosulfan gave some control the following season. Experimentally, carbofuran applied as a foliar spray and aldicarb applied subsurface are promising. Aldicarb did better in years with higher rainfall.

P21.-  
7

THE INFLUENCE OF TURFGRASS THATCH ON INSECTICIDE  
PENETRATION AND CONTROL OF SCARABAEID LARVAE.

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Organophosphate and carbamate insecticides are used extensively to control various species of soil-inhabiting scarabaeid larvae in turfgrasses on home lawns and sport fields. Laboratory and field data verified that variability in control provided by these insecticides was largely due to the degree to which they are bound to the layer of organic matter (thatch) through which they must pass to reach the target pest. Various insecticides were characterized as to their binding properties.

P21.-  
8

INSECT MANAGEMENT STRATEGIES ON CUCURBITACEAE IN INDIANA

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Historically insect control on melons has been the repeated application of insecticides to foliage to kill the striped cucumber beetle (Acalymma vittatum) and the spotted cucumber beetle (Diabrotica undecimpunctata howardi). Ten to twelve applications are often necessary as control of these insects is the only available mechanism for controlling bacterial wilt disease of cucurbits caused by Erwinia tracheiphila. The environmental effects of repeated applications of carbaryl, the most commonly used material, have been particularly severe on pollinators. Honey bees are particularly susceptible to carbaryl poisoning resulting in pollination deficiency and yield reduction. We have recently discovered that in addition to the direct feeding damage of cucumber beetles and the transmission of bacterial wilt, feeding by larval cucumber beetles on the roots of melons is causing a significant reduction in growth of melons. The strategy of applying granular carbofuran to the soil prior to planting has reduced both adult feeding and bacterial wilt transmission and in addition larval damage to the roots. Foliar spraying has been significantly reduced or eliminated as has been the hazard to pollinators and other non-target organisms. Yield increases have resulted probably due to increased pollination, reduced phytotoxicity, and reduction of larval feeding.

P21.-  
9

PRAYS OLEAE AND PALPITA UNIONALIS: ABUNDANCE IN SOME OLIVE  
VARIETIES THROUGHOUT THE YEAR AND CHEMICAL CONTROL

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The abundance of Prays oleae and Palpita unionalis differed according to the variety of the olive host and the season. The least infested variety for both pests was Shemlaly; the most susceptible, Cirpessino.

The population of each pest showed marked peaks, which varied somewhat in number, size and timing with the olive variety. Generally, the highest numbers of Prays oleae larva were found in July and September. Very low numbers were counted from October through March. Palpita unionalis larva were most abundant in September. No larva were counted from January through March.

Rogor 40L, Anthio 33EC, Gardona 70% EC, Murfotox 68% EC and Azodrin 40 WP were field tested. Three sprayings of Gardona (0.12% a.i.) or Rogor (0.0525% a.i.) at 3-week intervals were recommended against Prays oleae. Three sprayings of Gardona (0.12% a.i.) or Anthio (0.066% a.i.) at 3-week intervals were recommended against Palpita unionalis.

P21.-  
10

CONTROL OF CATERPILLARS ON CABBAGE WITH INSECTICIDE BAITS

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Cabbage growers in Florida use high pressure and volume sprays 6-8 times during the growing season to control cabbage loopers, Trichoplusia ni, and diamondback moths, Plutella xylostella, on the crop. As an alternative to the use of expensive sprayers and large amounts of water for control of these insects, acephate insecticide baits were applied 1-5 times per season over the tops of cabbage plants grown in the field during 1982 and 83. Test results showed that caterpillar control with baits applied 5-6 times was comparable to 6 weekly sprays and was highly superior 2 weeks after the last application when that obtained with sprays declined markedly.



**P21.-** EFFECTS OF PRECOCENE II ON OVARIAN FOLLICLE DEVELOPMENT AND  
**11** VITELLOGENESIS IN SPODOPTERA MAURITIA BOISD. (LEPIDOPTERA:NOCTUIDAE)

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In many hemimetabolous insects, precocene II (PII) with its antiallatal activity, inhibits the juvenile hormone controlled processes of reproduction. In the present work we subjected pupae and adults of Spodoptera mauritia to different treatments of PII and studied their effects on ovarian follicle development and vitellogenesis. Topical application of a single dose of 100 µg or 200 µg of PII to pupae immediately after ecdysis (0-hr) was lethal. 0-hr pupae treated with 80 µg PII ecdysed normally but the eggs laid by adults were non-viable. Females emerged from pupae which were treated at 0-hr with 60 µg PII laid viable eggs.

Single treatment of 0-hr adults with 60 µg, 80 µg or 100 µg PII resulted in normal follicle development and vitellogenesis. However, repetitive treatment of adults at 0-hr and at 3-hr after emergence with 100 µg PII, blocked further development of follicles. Histological and trypan blue uptake studies on ovarioles 24 hrs and 48 hrs after treatment showed that maturation of follicles and exogenous protein incorporation has been inhibited. The follicles also showed many developmental defects. Allatectomy on 0-hr adults produced a similar effect on follicles.

**P21.-** COMPARISON OF ALTOZAR AND DDT EFFECTS ON TICK FEMALES  
**12** DURING AND AFTER FEEDING

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Ixodes persulcatus females were treated with one of two active substances from different groups at one of six consecutive time-points during the period beginning with attachment and ending with the commencement of oviposition.

The moment of tick attachment (point 1) appeared to be the most sensitive time for the action of Altozar; a delay of detachment of some part to the engorged females was observed, as well as a decrease in their mean weight and undetachment of a considerable part of the females during a long period. Similar effects were observed when Altozar was applied on the 1st and 3rd days after the attachment (points 2 and 3) although in the first case they were less pronounced. Altozar treatments on the 5th day of feeding, shortly before oviposition, and especially immediately after detachment (points 4, 6, 5, respectively) mainly resulted in the non-viability of the laid eggs.

DDT was absolutely ineffective when it was applied at point 1. DDT treatments of ticks at points 3 and 5 were highly effective: this was expressed by a reduction in weight of the engorged females and a suppression of their fecundity in the first case, and death of all the larvae at different terms after hatching in the second one. Many larvae also perished when the ticks were treated with DDT at point 6. Ticks were quite tolerant to DDT action when they were treated at points 2 and 4. - The both compounds action ultimately resulted in the inhibition of tick reproduction but its rate and way depended on the compound applied as well as on the time of treatment. Altozar effects after its treatments at points 1-3 may be considered as specific (hormonal).

**P21.-** SYSTEMIC EFFECTS OF A NEEM EXTRACT ON HEMIPTEROUS INSECT  
**13** PESTS

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Systemic application of a neem seed extract affected growth and fecundity of the rice hopper pests Nilaparvata lugens (Stål), So-gatella furcifera (Horváth), and Nephotettix virescens (Dist.) (Cicadellidae). Concn  $\geq 1$  ppm significantly retarded growth of first instar hopper nymphs on treated rice plants. The reproductive potential of the insects was significantly reduced upon a short-term exposure of females to rice plants treated with 5 - 50 ppm of the extract; longevity of the treated females was not affected.

The same extract also affected growth and survival of first instar Aphis fabae Scop. and Acyrtosiphon pisum (Harr.) nymphs (Aphididae), and third instar Piesma quadratum (Fieb.) nymphs (Piesmitidae) on treated host plants. The extract's efficacy increased by adding sesame oil, and additional formulation with phospholipids caused further improvement.

**P21.-** THE EFFECT OF CRUDE EXTRACTS OF AJUGA SPECIES  
**14** ON METAMORPHOSIS OF MOSQUITOES

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With regard to the use of plant extracts as easily producable and non-hazardous pest control agents crude methanolic extracts of dried parts of the various phytoecdysons containing Labiatae Ajuga remota and A. reptans were tested against eggs, larvae and pupae of Aedes aegypti, A. togoi, Culex quinquefasciatus and Anopheles stephensi.

Rearing first instar larvae until emergence of adults in treated water caused a slight acceleration of development. Mortality occurred mainly during larval - pupal ecdysis (root extract) or in late pupal stage (extracts from green parts) after treatment of young fourth instar larvae until adult emergence. Extracts of A. reptans are more effective than those of A. remota.

Sensitivity of the mosquitoes decreased from first larval instar to pupa, but differed not much between the four species tested.



Section 22	Special Themes .....
S 22.1.	<i>Phylogeny, Bionomics, and Ecology of Water Striders (Hemiptera, Gerridae)</i> .....
S 22.2.	<i>Second International Symposium on Neuropterology</i> .....
S 22.3.	<i>Symposium on Cecidology – Plant-Insect-Relations in the Special Case of Galls</i> .....
P 22.3.	.....
S 22.4.	<i>The Second International Conference on Classification, Phylogeny, and Natural History of Hydradeephaga (Coleoptera)</i> .....
S 22.5.	<i>Study and Utilization of Non-Mulberry Silkworms</i> .....
S 22.6.	<i>Didactics of Entomology</i> .....
S 22.7.	<i>Ecological Methods for Sampling and Registrating of Arthropods</i> .....
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S 22.8.	<i>First International Symposium on Chrysomelidae (Coleoptera): Biosystematics, Biogeography, and Evolution of Chrysomelidae</i> .....
W 22.9.	<i>Workshop on Cecidomyiidae: Morphology, Taxonomy, Ecology, and Control</i> .....
P 22.9.	.....
S 22.10.	<i>Cockroaches: Biology, Ecology, and Control</i> .....
W 22.11.	<i>Workshop on Microlepidoptera</i> .....

## S22.1. PHYLOGENY AND ECOLOGICAL EVOLUTION OF WATER STRIDERS 1 (GERRIDAE).

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Water striders of the family Gerridae are the most successful group of insects living on the surface film of water. They occupy almost any kind of aquatic habitat, including the open ocean (Halobates spp. or sea skaters). The functional morphology of these insects shows numerous adaptations towards life on the water surface and no single species group is distinctly more primitive than any other. It is, however, possible to define a number of monophyletic taxa within the Gerridae and to construct a reliable hypothesis of cladistic relationships between them from which the pathways of ecological evolution can be inferred.

**S22.1.** STRUCTURE, FUNCTION AND EVOLUTIONARY SIGNIFICANCE OF THE GYNATRIAL  
**2** COMPLEX IN FEMALES OF HEBRUS RUFICEPS (HEMIPTERA, HEBRIDAE)

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The gynatrial complex is an elaborate sperm storage and delivery system derived from the posterior common oviduct and genital chamber in female gerromorph bugs. In females of H. ruficeps it consists of a distensible gynatrial sac opening posteriorly into the base of the ovipositor. A tubular, basal thickening (=spermathecal bulb) is situated below this sac and opens posterodorsally into it via an elastic groove well supplied with dilator muscles. The thickening is continuous anteriorly with a long, coiled, spermathecal tube and, posteriorly with a fecundation canal, an elastic, thick-walled groove in the roof of the common oviduct that extends anteriorly to end in a fertilization chamber.

The skeletomusculature and glandular cells of this complex are described and its role in receiving, storing and releasing sperm during mating and oviposition are inferred from analysis of paired males and females separated at various times following onset of copulation.

Variation in the structure of the complex in other gerromorphs is alluded to and it is concluded that it evolved as a mechanism for releasing precise numbers of spermatozoa for fertilizing eggs.

**S22.1.** THE PHYLOGENY AND ZOOGEOGRAPHY OF NEW GUINEA GERROMORPHA  
**3**

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The Gerromorpha of New Guinea derived primarily from Asian stock. The Gerridae and Veliidae have radiated extensively in the lowlands and the latter in the highlands also. A number of genera are endemic or restricted to New Guinea and closely adjacent regions. Many species and genera are quite closely related indicating extensive speciation from relatively few founders.

**S22.1.** NEOTENY AS A POSSIBLE AGENT OF EVOLUTION IN THE GERRIDAE (HEMIPTERA:  
**4** HETEROPTERA)

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I hypothesize that neoteny served as an agent of evolution in the Gerridae (that neoteny precipitated some cladogenesis in the family). Results of cytogenetic, ontogenetic and morphometric study corroborate the hypothesis. (Here attention is given to morphometric study.) Results of morphometric analysis may be consistent, as well, with other hypotheses proposed to explain cladogenesis in the Gerridae, but in combination with corroborating cytogenetic and ontogenetic data may be considered as more consistent with the neoteny hypothesis. Morphometric analysis of variable data (measurements of 12 appendage segments in all instar stages) has been performed for gerrid species representing over 20 genera, using, in particular, Averoid's Method of Harman's factor analysis. Factor loadings extracted from the correlation matrix for the variables are compared: If an advanced clade (e.g., Metrocoris, Halobates) diverged from a less-advanced clade (e.g., Gerris, Ptilomera) by neoteny, the factor loadings for the early instar stages of the thusly related advanced and less-advanced clades should match more closely than one would expect on the basis of chance. For some gerrid clades such matches exist.

**S22.1.** ECOLOGY OF THE OCEANIC HALOBATES.  
**5**

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Few insects can tolerate seawater, let alone live in the sea. The ocean-skater Halobates is the only insect genus known to inhabit the open ocean, hundreds of kilometres away from land. Unlike its freshwater relatives it has become independent of land for reproduction and has evolved a number of adaptations to cope with accidental submergence or drowning, continuous exposure to solar insolation, and mate-finding in a featureless environment totally devoid of land-marks, etc. It feeds largely on marine zooplankton trapped at the air-sea interface; in areas closer to shore it may feed on insect flotsam. Its main predators are seabirds, which can cause considerable mortality to some ocean-skater populations. It may pass on pesticides and heavy metals, which it accumulates from its food and water, to its seabird predators.

**S22.1.** COMPARATIVE ECOLOGY OF THE OCEAN STRIDERS (HALOBATES:  
**6** GERRIDAE) OF FIJI AND THE GALAPAGOS ISLANDS

Dr. W.A.FOSTER

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A comparative account of the biology of Halobates fijiensis Herring from Fiji and Halobates robustus Barber from the Galapagos Islands, Ecuador will be given. The influence of the contrasting habitats and morphology of the two species will be examined, and the food, feeding behaviour, reproduction, natural enemies, and predator avoidance behaviour of the two species will be discussed.

**S22.1.** "DIAPAUSEZEICHEN" (SIGNS OF DIAPAUSE): A NEWLY FOUND  
**7** PHENOMENON IN GERRIDAE (HEMIPTERA)

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Imagines of Gerridae laboratory-reared under short-day conditions from the egg develop a characteristic coat of numerous small and evenly spaced brownish particles of amorphous appearance covering the whole body including the veins of the upper wings before entering reproductive diapause. The phenomenon is the same in the free-living specimens of the genus, least pronounced in *G. najas*. It only shows preparatory to diapause, and is never seen in animals reproducing shortly after imaginal moult. We therefore named it "Diapausezeichen" (sign or indication of diapause).

The granules on the body surface are in all probability of endogenous origin, a kind of secretion; but so far nothing more is known about them. We are now at the beginning of an investigation into genesis and development of the "Diapausezeichen" by scanning microscopy and other techniques, and we propose to report on our findings at the congress next year.



S22.1.

8

STUDIES OF THE WING-POLYMORPHIC ADAPTIVE COMPLEX IN THE  
WATERSTRIDER, LIMNOPORUS CANALICULATUS

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As part of an ongoing study of the wing-polymorphic adaptive complex in the waterstrider, Limnopus canaliculatus, three fitness-associated traits were investigated in the longwinged and wingless morphs of this species. The longwinged morph exhibited significantly higher survivorship than the wingless morph under laboratory-simulated overwintering conditions and results were consistent with dramatic changes in morph frequencies during the overwintering period in natural populations. In contrast, the wingless morph exhibited significantly faster rate of nymphal development. Wingless females also laid more eggs than the longwinged females and the difference was particularly pronounced during the early stage of the reproductive period. Implications of these results to the dynamics of wing polymorphism in natural populations of this species will be discussed. Results of experiments currently in progress to identify the biochemical bases of these fitness differences and the hormonal co-ordination of the traits comprising the wing-polymorphic adaptive complex will also be discussed.

S22.1.

9

RELATIVE IMPACTS OF MORTALITY FACTORS IN FIELD POPULATIONS OF  
*GERRIS BUENOI* SAY (HETEROPTERA: GERRIDAE)

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Exclosure experiments and field observations were used to evaluate influences of cannibalism, intraspecific competition, food limitation and predation on populations of *G. buenoi* in central Alberta, Canada. Egg to adult survivorship was highest when predators were excluded and supplementary food was added to the same exclosures, and lowest when gerrids were held under ambient, natural conditions. Elimination of other aquatic and semi-aquatic predator/competitors had a larger impact on survivorship than addition of food supplements alone. Data from a serial addition experiment show that presence of young instars did not increase survivorship or weight gain of older nymphs. Patterns of weight gain suggest that competition among stages had more impact than cannibalism. Data collected about prey use in several natural populations provide little evidence for significant rates of cannibalism, even during periods of severe natural food shortage. It is concluded that population size for *G. buenoi* is limited chiefly by food shortage in interaction with predation by several taxa of aquatic invertebrates.

**S22.1.** POPULATION DYNAMICS OF THE COMMON EUROPEAN WATER-STRIDER  
**10** GERRIS LACUSTRIS (GERRIDAE, HEMIPTERA)

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For three successive years we studied the dynamics of the adults in a predominantly (over 90%) short-winged population of *Gerris lacustris*. By using the stochastic model of JOLLY and SEBER and by individual marking (= numeration) of virtually every single imago we obtained very reliable continuous estimates for the relevant population parameters such as density, survival, residence, immigration, emigration and productivity.

The population proved to be partially bivoltine. The number of immediately reproducing females of the summer generation, though depending on the weather conditions in early summer, was always quite small compared to the overall production of approximately 2000 adults each year. The majority, liable to diapause, were leaving the water surface 3 to 5 weeks after the final moult. In spring 30 to 40% of the marked short-winged individuals but only very few of the long-winged reappeared on the water. Most of the long-winged colonizers proved to be unmarked immigrants of "foreign" origin.

**S22.1.** THE DISTRIBUTION OF WATERSTRIDER LARVAE IN RELATION  
**11** TO HABITAT MICROSTRUCTURE, FOOD AND IMAGOS

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Results of field and laboratory studies on several *Gerris* species are reviewed, and the adaptive significances of and reasons for microhabitat shifts are discussed.

**S22.1.** MICROGEOGRAPHIC VARIATION IN THE POPULATION ECOLOGY OF A  
**12** STREAM-DWELLING GERRID, GERRIS REMIGIS.

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Gerris remigis are large, primarily apterous, stream-dwelling waterstriders. This study compares the population ecology of G. remigis living in 2 distinct stream habitats: (i) a relatively warm, stable pond created by a man-made dam, and (ii) a 100 m stretch of riffles and pools along a cool mountain stream. Populations of G. remigis found at these 2 sites are compared using iterative mark-recapture techniques, with data from over 2500 individuals. Although the 2 sites lie within the same watershed, and are separated by less than 1 km, populations at these sites differ markedly with respect to phenology, reproductive success, proportion of winged individuals, mean body size, and rates of emigration and immigration. Hypotheses relating these differences to water temperature, habitat stability, food availability, and barriers to dispersal over land and water are examined. The possibility of reproductive isolation and genetic divergence of the population at the pond site is also addressed.

**S22.1.** The effect of daily food ration on the life-history parameters  
**13** of Gerris thoracicus, a denizen of unpredictable environments

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The daily amount of food was varied in laboratory rearings of G. thoracicus (minimum one drosophila, maximum superabundant insect food). The reproductive output (= number of eggs), life time, and egg viability were measured. Results indicate that food shortage almost totally arrested egg laying while lifetime was lengthened, to over two months in many cases. Alternating 10-day periods of minimum ration with those of superabundant food, caused females to lay more eggs per batch than with continuous superabundant food. The ration had no clear effect on egg viability nor on the development time of an egg. The observed longer life time during food shortage may explain the long life time of some G. thoracicus individuals in nature, although the variability of the length of the reproductive period was high also in females with superabundant food.

**§22.1.** DYNAMICS AND STRUCTURE OF A VELIA CAPRAI (TAM.) POPULATION  
**14** ALONG A SOUTH SWEDISH STREAM

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By comparing six stations within a section of 7 km in the upper part of a stream, density as observed from active animals varied significantly. High numbers ( $> 1000$  specimens  $100\text{ m}^{-1}$  stream section) were found at the intermediate stations. Macropterous specimens (mainly females) were only found at these stations. During summer, when the new generation emerged, females and males were equally abundant but females dominated during autumn and especially during spring (approx. 13:1). Time for emergence of young water crickets varied between the stations. Effects on population density of predation by brown trout as well as food supply in the form of surface drift were investigated. Individual weight of imagines varied seasonally, and also here differences between stations were observed. Reasons for the observed differences are discussed.

**§22.1.** ALTERNATIVE TERRITORIALITY STRATEGIES IN A WATER STRIDER  
**15**

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Males and females of Gerris remigis exhibit food threshold territoriality, defending edge, riffle, and center territories (and combinations of these) in small streams. Studies of a) territory value in terms of probability of food capture, b) riffle/edge combination-territory time budgeting, and c) riffle/edge/center territory choice experiments, show that riffle and edge territories have much greater food capture potential than center territories, and that given a choice, striders distinctly prefer riffle territories over edge or center territories. Males are notably dominant over females in territoriality. Food threshold territoriality does not appear to be involved with mating behavior in remigis even in populations in which some striders are mating as well as being territorial.

## **S22.1.** ALTERNATIVE MATING STRATEGIES IN THE WATER STRIDER GERRIS ELONGATUS. **16**

Hayashi, K. ( Dept. Biol. Fac. Sci. Kyushu Univ. Fukuoka 812 Japan )

Males of water strider Gerris elongatus established territories including oviposition and copulation site. The number of suitable sites for territory was limited, and struggles for territory or female among males were observed frequently. Males used midlegs for fighting as weapon and their midlegs were more developed than female's (sexual dimorphism).

Three type of mating behaviour were observed during the breeding season. Type 1: In the early season immature females reacted to the courtship signals with surface waves by nonterritorial male and she copulated with him on free water surface without oviposition. Type 2: In the mid season females became mature and male established territory producing calling signals with surface waves to introduce females. Females came to the territory, copulated with him and oviposited there. Type 3: In the late season many females began to oviposit without guarding by male in pondweed mats near territories. Nonterritorial males waited for the arrival of these females there and copulated without any courtship, but the mating success was low.

These alternative mating strategies depended on the male size. Larger males of 90mm or more in midleg length took territorial strategy throughout the season and had higher mating success. Smaller males of less than 60mm took nonterritorial one. Males of intermediate size, 70-80mm took both strategies. Sometimes they were territorial while other times nonterritorial according to the number of empty territories and seasonal female distribution.

## **S22.1.** TERRITORIALISM IN WATERSTRIDERS - A SPECTRUM OF **17** ADAPTIVE STRATEGIES

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We describe different kinds of territories and territorial behaviour in two European waterstrider species (*Limnoporus rufo-scutellatus* (Latreille) and *Gerris najas* (De Geer), both belonging to Gerrinae) and in one African species *Eurymetra natalensis* (Distant), Halobatinae).

In the first species, only males are territorial, and in the second one only females. In *G. najas* an ESS has evolved where the male attaches permanently during the mating season to the female. In *E. natalensis* both the female and the male are territorial, but in different ways.

We discuss the adaptive significances of territorialism of each of the species and/or sex in relation to the differential cost of reproduction in the two sexes and the species-specific environments.

**522.1.** DISTRIBUTION, HABITAT PREFERENCES AND PHENOLOGY  
**18** OF GERROIDEA IN FLANDERS (BELGIUM).

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A large number of water bodies (5184) uniformly distributed over the whole of East and West Flanders and North-Eastern Limburg were sampled for semi-aquatic water bugs. For each sampling site, a number of environmental factors describing the water quality, vegetation and climate were determined.

Seventeen species of Gerroidea were gathered: Gerridae (8); Veliidae (4); Hebridae (2); Hydrometridae (2); Mesoveliidae (1).

In order to explain the distribution of these animals, we analysed the covariance of their occurrence and the aboved mentioned environmental factors, taking also into account their life cycle and their dispersal abilities.

**522.2.** THE RAPHDIOPTERA OF THE WORLD: A REVIEW OF PRESENT  
**1** KNOWLEDGE

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The order Raphidioptera comprises two markedly differentiated families, Raphidiidae and Inocelliidae, the distribution of which is confined to certain parts of the Holarctic: Europe; Asia except most tropical regions; NW-Africa; the Western parts of North America including Mexico. Significantly high numbers of species occur in the southeast of Europe, in Anatolia, in Central Asia, and in the southwest of North America. So far altogether about 170 valid species of Raphidiidae and 17 valid species of Inocelliidae have been known. Thus the main bulk of the recent species has been registered, the total will probably not exceed 220. Nearly all described species have been studied accurately, there are no major taxonomic problems with respect to identification. A few species (particularly in the Nearctic) are, however, rather polymorphic and polytypic thus involving some questions still unclarified. The larvae, biology, and autecology including parasites of almost all European and Mediterranean species have been studied in detail, in the field as well as in the laboratory, whereas the Raphidioptera of Central Asia are poorly known. A new generic classification has been prepared, Raphidiidae have been grouped into 28 genera, Inocelliidae into 5 genera. It is intended to publish a monograph of the order in near future.

## **S22.2.** THE CONIOPTERYGIDAE (NEUROPTERA) IN AMERICA

**2**

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From America 124 spp. of dusty wings are recorded, most of them quite recently and obviously still many spp. are to be described.

In South America the majority of the fauna belongs to four endemic generic taxa: Scotoconiopteryx, which obviously is very rich in species, most of which occur in the rain forest, Incasemidalis occurs in the Andean Region, Pampoconis in the southernmost parts of the continent and Neosemidalis in the north. Represented in both South and North America are the world widely distributed Coniopteryx (s. lat.) and Semidalis.

In North America five Holarctic generic taxa are represented: Aleuropteryx, Conwentzia, Helicoconis, Parasemidalis and Xeroconiopteryx. The monotypic Bidesmia is endemic. In eastern North America there are five and in western North America two species with a holarctic distribution. In the southernmost parts of North America, the Gondwanian element is represented by some Neoconis.

## **S22.2.** BIOGEOGRAPHY OF PALEARCTIC MYRMELEONIDAE (NEUROPTEROIDEA: PLANIPENNIA)

**4**

HERBERT HÖLZEL

A 9520 SATTENDORF, ANNENHEIM 160

In the Palearctic Region we know at present about 300 valid species of Ant-lions. Usually the family is divided into 2 subfamilies: Palparinae and Myrmeleoninae, both are represented in this region. The distribution of Palparinae is restricted to Southern Europe, Africa and Asia; 2 tribes Palparini and Echthromyrmicini are present.

The Myrmeleoninae are represented with 7 tribes: Dendroleonini (worldwide, centre in Southern Hemisphere), Distoleonini (world without America), Glenurini (worldwide, centre in Southern Hemisphere), Acanthaclisini (worldwide), Isoleonini (Southern Europe, Africa, Asia), Myrmecaelurini (Southern Europe, Africa, Asia), Myrmeleonini (worldwide).

S22.2.  
5

## DISTRIBUTION PATTERNS OF AUSTRALIAN MYRMELEONTIDAE

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The Australian Myrmeleontidae comprises 210 known species. Most of these are endemic, with the greatest radiations in the arid regions of the continent, but with some taxa limited to the more equable east and south. Distribution patterns of this large fauna are outlined and discussed.

S22.2.  
7 THE PRESENT STATE OF KNOWLEDGE ON THE FAMILY BEROETHIDAE

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Up to now the family Berothidae comprises about 90 described species so far grouped into four subfamilies: Rhachiberothinae, Cyrenoberothinae, Nosybinae, and Berothinae, the latter being rather heterogenous and representing the bulk of taxa. Their distribution includes warm-temperate and, mainly, subtropical and tropical areas of all continents and several islands with a maximum of species in Africa. Rhachiberothinae and Nosybinae seem to be confined to Africa, Cyrenoberothinae to South America, whereas Berothinae have a world-wide distribution. Berothidae are the sister-group of Mantispidae. The differentiation of Rhachiberothinae against Mantispidae has been a matter of discussion which has not yet been settled. So far, the biology of a single species (*Lomamyia latipennis* CARPENTER) has been studied, mainly under laboratory conditions. Nevertheless it may have representative character. The association of the larvae with termites and a non-feeding second instar may be obligatory. Otherwise, ecology of Berothidae is, however, almost completely unknown. At present most emphasis is given to taxonomy, and registration of species probably has just begun.



**S22.2.**  
**8**

CONTRIBUTION TO THE TAXONOMICAL STUDIES OF THE FAMILY  
ASCALAPHIDAE (NEUROPTERA) FROM EASTERN INDIA

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The paper incorporates the taxonomic account along with earlier investigation, salient morphological characters, brief review on classification and geographical distribution of the family Ascalaphidae under the suborder Planipennia of the order Neuroptera from Eastern India. Out of a total of fourteen species examined, male of Acheron trux loquax (Walker) has been described, two species, viz., Hybris angulata (Westwood) and Agrionosoma dohrni Weele redescribed, five species and two subspecies established as new locality records for the area under consideration. Running keys to all the taxa, their morpho-variations, relevant illustrations and references have been provided. Besides, the literature review of one more species has also been dealt with. Thus, an account of a total of fifteen species of Ascalaphidae from Eastern India has been furnished in the paper.

**S22.2.**  
**9**

THE FOSSIL PLANIPENNIA - A REVIEW

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A phylogenetic tree of the families of the order Planipennia is given, mainly based on the work of WITHEYCOMBE (1925) and informations from ASPÖCK et al. (1980), HENNIG (1981) and SCHLÜTER (1984). This classification is incomplete and the question remains whether the systematic relationships shown in the dendrogram really are well founded. But it represents a working hypothesis and hence it is possible to give additional data on the presumed stratigraphic and absolute age of the families of the Planipennia as shown by their fossil record.

Also biostratonomic implications of the main localities bearing well preserved fossil Planipennia are discussed.

## 522.2. THE HEMEROBIIDAE (NEUROPTERA) OF CANADA AND ALASKA

### 10

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As part of The Biological Survey of Canada (Terrestrial Arthropods), the taxonomy and geographical distribution of the Neuroptera is being studied. While we now have a good general knowledge of these for most families, rather little has yet been published. Information will be presented on the largest Canadian family, the Hemerobiidae. This is predominantly northern in distribution, almost all Nearctic species being found in Canada, some of them being Holarctic. Some Palaearctic introductions, ostensibly for biological control purposes, will also be noted.

## 522.2. FAUNAL RELATIONS OF AMAZON BASIN CHRYSOPINI (NEUROPTERA, CHRYSOPIDAE)

### 12

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<sup>1</sup>Calif. State Univ., Fullerton CA, U.S.A. <sup>2</sup>INPA, Manaus, Am., Brazil

Genera represented were Chrysopa (Plesiochrysa) with 2 species, Chrysoperla, 1 species, Chrysopodes, 9 species (7 new), and Ceraeochrysa, 14 species (8 new). Chrysopodes ranges from Mexico to Argentina; morphologically it is similar to a diverse assemblage of Suarius-like forms, with distinctive inflated mediuncus and very elongate bursal ducts, but differs in having sickle-shaped mandibles. Guts of most specimens contain setae and lepidopteran scales, but no small cuticular fragments. We suggest that probably adults feed on small Lepidoptera by perforating the cuticle and imbibing fluids. Suarius-like forms are common in Argentina, southern Brazil, the Andes, Central America and the Caribbean; their absence in the Amazon is noteworthy. Of the Ceraeochrysa species, 4 are widespread in neotropical agroecosystems, as are the Chrysoperla and Plesiochrysa species.

**S22.2.** RELATIONSHIPS BETWEEN THE NEUROPTERA OF AUSTRALIA  
**14** AND PAPUA NEW GUINEA

T.R. NEW  
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The Neuroptera of Australia include a number of presumed recent northern invasions from the Papua New Guinea area, mainly through Cape York - a well defined region for faunal interchange. Conversely, a number of southern elements do not extend northwards across Torres Strait. The extent of faunal overlap is appraised, and a synopsis given of the more unusual endemic Neuroptera of each country.

**S22.2.** RECENT INVESTIGATIONS IN THE NEUROPTERAN FAUNA  
**16** IN SOUTH-WEST GERMANY

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An extract will be presented from the investigations made during the last seven years in Neuropteroidea in the biogeographical interesting region of Upper Rhine Valley and Black Forest. Some of the species discussed are new for Germany.

**S22.2.** BIOLOGY AND LARVAL DIAGNOSIS OF MIDDLEEUROPEAN NEUROPTERA  
**19** ( A REVIEW OF PRESENT KNOWLEDGE)

Dr. Johann GEPP

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In the last twenty years the knowledge of the biology of middleeuropean Neuroptera (Raphidioptera, Megaloptera, Planipennia) was growing noticeable. Phenology, preferred habitats and distribution are known to some extent. Larvae of 93 (=80,9%) of all 115 species of Neuroptera living in Central Europe are known (Europe 163:303=53,8%). But only the half of them are at present sufficient described. The publication of a monography concerning the lecture's theme is projected for 1985.

**S22.2.** A CAUTIOUS UNIVOLTINE STRATEGY IN THE LACEWING *NINETA FLAVA* (SCOPOLI)  
**20** (NEUROPTERA, CHRYSOPIDAE).

M. CANARD

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A strain of *N. flava* originating from the southern part of its distribution area exhibited a single brood in a year. In the laboratory, the larvae entered always diapause within the cocoon, independently of the photoperiod rearing conditions. The extended duration for adult emergence after overwintering outdoors depended on the photoperiod monitored by the larvae developing before the prepupal diapause : short-day light conditions offered to them induced a hasty spring appearance and reversely. Besides, the long spread of egg-laying time may be due to the occurrence of an imaginal reproductive diapause displayed to certain females by long days.

The combination of these two acting factors : (i) ensures to the species a long-time occurrence in nature (imagines from May to October), (ii) gives it the phenological look of the multivoltinism, and (iii) prevents by contradictory results and by the variability in imaginal responses the separation of the population into separate sympatric biotypes.

**S22.2.** DEVELOPMENT AND FECUNDITY OF CHRYSOPIDS (NEUROPTERA)  
**24** ON CHEMICALLY DEFINED DIETS

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Several species of green lace-wings have been reared for several generations with lyophilized drone honey bee brood as a diet. An attempt to rear one of the species, Chrysopa nipponensis, on chemically defined diets was successful when the diets were composed of sucrose, trehalose, 6 fatty acids, cholesterol, 23 amino acids, 5 organic acids, 17 vitamins, and inorganic salts. Effects of altering relative composition (ratio of sugars to amino acids, and amino acids composition) were examined in order to improve the diets. The diets sustained good growth and oviposition by the insects as compared to the results obtained with drone powder, although growth of the second generation on the same diet was poor.

**S22.2.** Adult food of little known freshwater  
**27** Neuroptera: intestinal contents of  
Sisyridae and Osmylidae

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Analysis of the crop and gut contents of Adult S.terminalis and O.fulvicephalus revealed their carnivorous characteristics, as arthropod fragments were consistently found in both species. S.terminalis feeds mainly on aphids and to a lesser extent on eriophyid mites (rust mites). The existence of plant material in their intestine such as pollen, algae and fungi suggests that they may also feed on honeydew (homopteran anal secretion) on plant surfaces. O.fulvicephalus seems to have a wider carnivorous diet; aphid antennae and cornicles, Dipteran legs and wings, Lepidopteran larval legs and many mandibles of unidentified origin were found. The two species are of very different sizes; S.terminalis is minute (wing length: 5-6mm), O.fulvicephalus is one of the largest freshwater neuroptera (19-23mm). The relatively specialized food habit of S.terminalis could be due to its small size, whereas the larger O.fulvicephalus seems to be more general feeder. Despite their different appearance and detailed diet differences however, their general food composition was similar. Withycombe (1925) considered the two families to be closely related phylogenetically, sisyrids being derived from osmyloid ancestors.

## 522.2. Comparative morphology of the larval eyes in Neuropteroidea

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The fine structure of larval eyes (stemmata) of *Sialis* (Megaloptera), *Raphidia* (Raphidioptera), *Euroleon*, *Sisyra* and *Hemerobius* (all Planipennia) have been investigated to find further arguments for the evolution of stemmata from faceted eyes instead of often supposed myriapodan-like precursors. All species have 7 eyes on each side of the head with an eucon crystalline cone consisting of 5 (*Sisyra*), 6 (*Hemerobius*), 7 - 8 (*Raphidia*, *Euroleon*) or 8 (*Sialis*) Semper cells. The monaxonal retinulae are constructed in different ways, partly depending on larval stage. Fusion of original two adult ommatidia (consisting of 4 Semper- and 8 retinula-cells each) is probably the evolutionary pathway to form a stemma in Neuropteroidea. It will be discussed the phylogenetic relationship to the stemmata of other Holometabola especially to the possible sistergroup Coleopteroidea.

## 522.2. FLIGHT ACTIVITY PATTERNS IN LACEWINGS (PLANIPENNIA: CHRYSOPIDAE)

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Flight activity patterns of various chrysopid species were investigated in laboratory experiments. The influence of external stimuli such as light, temperature, humidity and food were tested. Wing beat activities of lacewings kept in plastic containers were monitored by extremely sensitive microphones connected to an event recorder. Three types of diel flight activity patterns were observed:

- (1) The carnea-type, where flight starts after sunset and ends before sunrise. Most chrysopids show this type of activity.
- (2) The perla-type, where flight starts in the afternoon and ends after the onset of total darkness.
- (3) The basalis-type, where flight has two twilight peaks, one at dusk and one at dawn.

Thresholds for ambient illumination and temperature were determined in temperate and tropical species. Most carnea-type lacewings fly below ca 10 Lux. Between 11° and 23°C flight activity is a linear function of temperature. The light regime has an influence as "Zeitgeber" for diel (circadian) rhythms, but only via vernalism on seasonal flight phenology, which depends primarily on temperature.

**S22.2.** CARBOHYDRATE CONTENT VARIATIONS IN *CHRYSOPA WALKERI* McLACHLAN  
**33** (NEUROPTERA, CHRYSOPIDAE) DURING ITS PREPUPAL DIAPAUSE.

J.C. SAGNÉ

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Glycogen- trehalose-, and glycerol level were studied in *Chrysopa walkeri* during diapause development at constant temperatures. Analysis were carried out on whole crushed prepupae. Glycogen content was determined after hydrolysis conversion to glucose by  $\alpha$ -glucosidase with a standard glucose analyser. Trehalose and glycerol were measured by gas chromatography. Two thermic conditions were used, simulating : (i) aestivation at relatively high temperature (20°C), (ii) wintering at 5°C.

During aestivation, glycogen level was very unequally distributed in individuals and trehalose level was low. During wintering trehalose level increased, glycogen one decreased and detectable glycerol occurred. The break of diapause was related to changes in carbohydrate amounts : (i) increase of glycogen, (ii) decrease of trehalose and (iii) glycerol run off.

**S22.3.** THE FORMATION OF PLANT GALLS. WHO IS IN CHARGE, THE INSECT OR THE  
**1** PLANT?

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The appearance of plant galls due to the actions of select insects represents one of the most complex associations known to exist between insects and plants. Gall insects apparently have evolved the ability to control the expression of the latent genetic potential of plant cells and redirect plant growth into patterns foreign to the host organ but advantageous to the insect. By applying as yet unidentified stimuli, host plants are provoked into surrounding feeding sites with specialized cells which provide the insect with nutrition and a sheltered chamber.

The main events in the formation of galls (initiation, growth, and development) are reviewed and illustrated in this paper by examining 3 model systems:

- a. shoot galls induced by the chalcid wasp Hemadas nubilipennis on Vaccinium angustifolium
- b. stem galls induced by the tephritid fly Urophora cardui on Cirsium arvense.
- c. leaf galls induced by the cynipid wasp Diplolepis polita on Rosa acicularis

Initiation and growth are under the control of the insect; however, the plant exerts some control over tissue maturation and differentiation.

## S22.3.

2

### FOSSIL GALLS

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Two fossil acorns of Quercus agrifolia Mee are described that show damage typical of that caused by extant cynipid wasps such as Callirhytis milleri Weld. These two examples are included in a checklist of described fossil galls. Summary comments about the longevity of the gall-forming co-evolutionary habit are drawn from the checklist.

## S22.3.

3

### THE PHYLLOXERIDAE (HOMOPTERA: APHIDOIDEA) AS GALL FORMERS ON CARYA, NYSSA, ULMUS, AND VITIS

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The Phylloxeridae join with the Aphididae and Adelgidae to make up the Aphidoidea. The family Phylloxeridae is largely North American and is best known for the one species that forms galls on the leaves and roots of Vitis spp. However, many species of phylloxerans produce galls on Carya spp.; and four species are pests of pecan in Texas. One species forms galls on the leaves of Ulmus, and one species forms galls on the leaves of Nyssa. Those species found on Quercus and Castanea curl the leaves but do not produce galls.



### 522.3. AGE AND POPULATION CORRELATED MORPHISM IN SOME NATURAL 4 AND INDUCED THIRPS GALLS AND ASSOCIATED TISSUE DYNAMICS.

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Varying populations of larvae and adults of gall thrips in natural and/or induced gall systems, appear to considerably influence not only the size and shape of the galls, but also the surface area, thickness, dry weight as well as the degree of hyperplasy and hypertrophy. The age of the gall and involved population of thrips therefore also tend to influence the dynamics of tissue reactions which appear to differ appreciably in natural and induced galls. Increasing diversities both in the expression of external form as well as the pace at which differentiation takes place in induced galls are discussed with reference to the leaf fold galls of Mimusops elengi. A comparative assessment of the changes occurring in natural galls as a consequence of age in terms of days and varying populations of thrips, has been made in the pouch galls of Calycopteris floribundus, as well as in the hypophyllous and epiphyllous galls of Vitis lanceolaria and Loranthus elasticus respectively.

### 522.3. 8 NUTRITIVE TISSUE IN MIDGE GALLS

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Nutritive tissues of midge galls appear by transdifferentiation of epidermal, mesophyll and cortical cells. Cell metaplasia occurs as a relatively uniform phenomenon in all midge galls studied and is characterized by an activation of cell turnover and high proteosynthesis. The vacuome is reduced. The cytoplasm, enriched in organites, is abundant. Chloroplasts' structure and position in the cell are modified, cell polarity is disturbed.

The nutritive tissue develops during gall growth, intimately related to larval behavior. At the beginning of the last larval instar the nutritive tissue is well developed : two main types appear, the most common is a tissue which facilitates the transport of solutes from the vascular tissues of the gall toward the larval cavity (numerous large areas of plasmodesmata, irregular cell walls and an abundant and smooth ergastoplasma are present). The second type of nutritive tissue first functions as a food attractor, a nutritive pad develops, enriched in protein, carbohydrates and oil. Later, when the larva needs a maximum of food, the cell content and even the cytoplasm of the nutritive cells become hydrolyzed and cell autolysis occurs.

**522.3.** RESPONSES IN LEAF EPIDERMIS CELLS TO ATTACK BY GALL MITES :  
**9** HAIR PRODUCTION

E. WESTPHAL

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When attacked by gall mites, leaf epidermal cells undergo considerable modification including differentiation of nutritive cells and/or hair production. In the simplest galls, mites cause their host to produce locally an excess of hairs (erinea), which may be uni- or multicellular, lobated or ramified. Normal glandular hairs of the leaf become rare and may show various shapes from near normal glandular trichomes to pathological non-glandular trichomes, displaying a progressive loss of secretory function.

**522.3.**  
**10** DEVELOPMENTAL PATTERNS IN THE LEAF GALLS OF THYSANOPTERA

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Cecidogenesis begins with the dedifferentiation of epidermal and the subjacent layers of mesophyll within 24-48 hrs of feeding injury inflicted by thrips, followed sequentially by enlargement and proliferation of the mesophyll. Specific proliferation patterns control the specific patterns of 'gall form', such as epiphyllous or hypophyllous leaf folds/rolls. A tendency to form closed galls, though rare, the incidence of necrosed cells along the nutritive zone, and the participation of many individuals in the galling process suggest cecidogenetic affinity to galls induced by Homoptera.

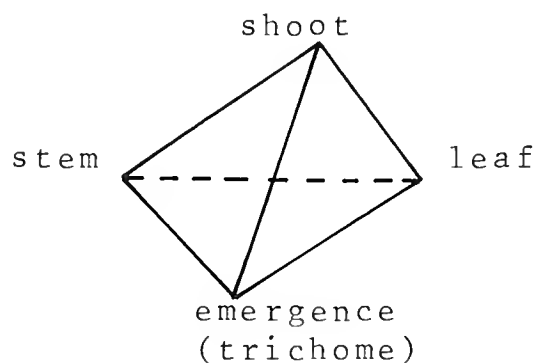
**S22.3.** ATYPICAL MORPHOGENESIS IN *FRAXINUS ORNUS* L. UNDER THE  
**11** INFLUENCE OF *ACERIA FRAXINIVORA* NAL.

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According to the classical model of plant construction, flowering plants consist of three mutually exclusive kinds of organs : root, stem and leaf. Morphogenesis of galls in *Fraxinus ornus* under the influence of the mite *Aceria fraxinivora*, contradicts the classical model and provides evidence for an alternative concept, namely a continuum model that posits intermediate forms between classical categories. The present findings support the following scheme in which both the hierarchy and discreteness of categories is replaced by a multi-dimensional continuum :



**S22.3.** HISTOLOGICAL AND PHYSIOLOGICAL STUDIES ON INSECT INDUCED  
**13** GALLS OF EMBLICA OFFICINALIS GAERTN.

UMA KANT

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This study is concerned with the histopathology and Physiology of stem gall on Embllica officinalis Gaertn. induced by Betousa stylophora Swinhoe. Galls are globose, fusiform, compressed, terminal and internodal. The cortex is highly proliferated and comprised of 14-20 layers of cells. The vascular cylinder is reduced in extent and the diameter of vessels is smaller compared to normal. The nutritive zone is formed by pith and medullary ray cells.

The gall and normal tissues were isolated and maintained on Murashige and Skoog's medium for in vitro studies. Effects of auxins like IAA, NAA and 2,4-D (ranging from 0.0 - 20.0 mg/L) on growth, sugar and phenolic contents of gall and normal callus tissues was studied. The total soluble sugar and phenolic contents of gall tissues were higher as compared to normal at all levels of auxin tested. Effect of phenolic acids (caffeic acid, trans-cinnamic acid, ferulic acid and p-hydroxybenzoic acid) on growth, sugar and phenolic contents of normal and gall tissues was studied. IAA oxidase and polyphenol oxidase activity of gall and normal counterpart was also determined.

**S22.3.**  
**14**

### LIPIDS, PHOSPHOGLYCERIDES, AND PHOSPHOLIPASE-ACTIVITY IN NEUROTERUS GALLS

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Several biochemical aspects of membrane lipid composition were studied in insect-transformed tissue (cecidia induced by Neuroterus quercus baccarum L. on black oak). In young, developing galls the total lipid content coincides with that found in non-transformed leaf cells. In mature galls, however, the amount of total lipid drops to about one tenth of that detected in immature cecidia. The composition and concentrations of plant phosphoglycerides (phosphatidylcholine [PC], phosphatidylethanolamine [PE], phosphatidylglycerol [PG], phosphatidylserine [PS], phosphatidylinositol [PI], and cardiolipin [CL]) are the same in young and in mature galls. However, except for PC, normal leaf tissues contain significantly higher levels of PG, PE, PS, PI and CL than galls. An increase in lipolytic hydrolase (phospholipase) activity was detected in galls, coinciding with earlier observations on defects in the regulation of fatty acid synthesis and on the deranged control of enzyme biosynthesis in neoplastic cells. In view of the altered phospholipid content and the increased activity in lipid acyl hydrolase in cecidia, we conclude that insect-transformed cells are not only characterized by their histological specialization, but also by changes in biochemical parameters at their cellular membranes.

**S22.3.**  
**15**

### THE PHENOLIC CONTENT OF YOUNG BUDS IN RIBES VARIETIES RESISTANT AND SUSCEPTIBLE TO CECIDOPHYOPSIS RIBIS

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Black currant reacts on infestation by the gall mite *C. ribis* with the symptom of "big buds", whilst varieties of red currant and gooseberry show different degrees of resistance. The phenolic content of young buds (August) was investigated in the following varieties: "Rosenthals Schwarze Langtraubige" and "Silvergieters Schwarze" (*R. nigrum*, susc.), "Rondom" and "Rote Vierländer" (*R. rubrum*, res.), "Weiße Triumph" (*R. uva-crispa*, res.), "Josta" (double hybride of "Rosenth.Schw.Langtr.", *R. divaricatum*, "Silvergieters Schw." and "Weiße Triumph"). The extraction method yielded as well glycosides as aglycones, which were separated by thin layer chromatography. There were large differences in the phenolic pattern between the varieties. Gall formation in *R. nigrum* was accompanied by changes in the phenolic pattern.

**S22.3. OVIPOSITION BEHAVIOR IN *DIPLOLEPIS* (CYNIPIDAE, HYMENOPTERA)**  
**18 INDUCING ROSE LEAF GALLS**

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Cynipid wasps of the genus *Diplolepis* are all gall formers restricted to the plant genus *Rosa*. *Diplolepis rosae* (L.) induces the well-known "bedeguar gall" with a dense mass of branched and sticky filaments, while *Diplolepis mayri* (Sch.) forms a gall more sparsely covered with short unbranched spines. The oviposition behavior of the two species is described as is also the eggs' structure and the foremost reactions of the plants. It's striking to note the great similarity of these two insect species which induce two such different galls.

**S22.3. DELAYED COLONISATION OF RECENTLY INTRODUCED GALL WASPS**  
**19 (HYMENOPTERA, CYNIPIDAE) BY PARASITES IN ENGLAND**

R. R. ASKEW

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Galls of *Andricus quercuscalicis* (Burgsdorf) were first found on *Quercus robur* in England (Northamptonshire) in 1961, and those of *A. lignicola* (Hartig) in four south-eastern counties in 1973. Both species have subsequently expanded their ranges to include most of England and Wales and galls of the agamic generations are often very abundant. A third and allied species, *A. kollari* (Hartig), was introduced into Devon in the mid-nineteenth century and is now found in almost all parts of the British Isles. All of these species have a sexual generation that forms galls on *Quercus cerris*. A factor that has probably contributed much to the recent successful colonisation of England by *A. quercuscalicis* and *A. lignicola* is the very low level of mortality inflicted on the agamic generations by hymenopterous parasitoids and inquilines. In continental Europe agamic *A. quercuscalicis* is recorded as parasitised by at least twelve chalcid species and five species of inquiline *Synergus*, and the agamic gall of *A. lignicola* is attacked by sixteen chalcid species and five *Synergus*. All of these associated species occur in Britain, attacking galls of other gall wasp species including *A. kollari*, but as yet they have failed to significantly colonise the new host resource provided by *A. quercuscalicis* and *A. lignicola*. Possible reasons for delayed incorporation of recently introduced species into the host spectra of parasitoids are discussed.

**S22.3.** PLANT GALLS BY PEMPHIGID APHIDS (HOMOPTERA)  
**20** IN THE HIMALAYAS

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Among the 'Zoocecidogenic agents', aphids forms a formidable group. Studies on the Pemphigid aphids in Indian region reveal that at least 21 species produce galls mainly on plants viz.

Ailanthus glandulosus, Carpinus viminea, Lonicera spp., Populus spp., Pistacia sp., Ranunculus sp., Syringa emodi, Toona ciliata, Ulmus spp., and on some unidentified plants. Different types of galls viz., covering galls, pouch galls, leaf roll galls etc. are produced on leaves, petioles or on stems of the above plants. Pemphigid aphids are known to lead heteroecious holocyclic life and produce galls on their primary host plant. But studies on this group also reveal the existance of some species having autoecious holocyclic life in the area. Intensive studies on some species exhibit some interesting phenomena on the behaviour of nymphs during gall initiation.

**S22.3.**  
**21** NEOTROPICAL GALLS

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Dept? Biol. Geral, Inst. Ciên. Biol.-UFMG; CP.2486.; 30000-B.Horizonte; BRASIL

Most of the previous studies on insect galls in the Neotropical region have dealt only with taxonomic aspects of the cecidogenic insects or with the morphological aspects of the galls. Our studies on Brazilian galls represent a comprehensive survey in a secondary sucessional area and in the Savanna vegetation. presently, 73 different types of shrubs and trees galls have been surveyed. The cecidomyiids are the most frequent gall makers ( approximately 70% ). These gall midges occur mainly under leaves and leaflets' surfaces. Most of galls are closed in a one-chamber-one-larvae. Presently own studies concentrate on the effects of plant architecture, altitudinal gradients in galls community changes and populations dynamics of some insect galls.

**P22.3.-** ON SOME NEW OR INTERESTING CYNIPID GALL-MAKERS (HYM. CYNIPIDAE) FROM SPAIN  
**1**

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Instituto español de Entomología c/ J. Gutierrez Abascal 2  
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A list is provided of some new or otherwise interesting species of Cynipid gall-makers (Hym. Cynipidae) collected in Spain mainly on Quercus ilex and Quercus suber.

The agamic alternate generation of Plagiotrochus amenti Tav. who galled twigs on Quercus suber L. is described.

The following species are recorded by first time for Spain: Callirhytis rufescens Mayr ♂♀ and ♂, Neuroterus cardiguensis Tav., Plagiotrochus britaniae Barbot., P. razeti Barbot., Phanacis lampsanae (Perris) and P. cichorii (Kieffer) and also the bisexual generation of Callirhytis glandium (Gir.) and the agamic of Plagiotrochus australis (Mayr) (= cabrerae).

**P22.3.-** GALLS AND HOST PLANTS OF ADELGIDS  
**2**

C.I. CARTER

Nine holocyclic species of gall-making adelgids have become established in Britain. These feed exclusively on coniferous trees that have been brought together from various parts of the Northern Hemisphere. The form of the galls on the various exotic species is displayed. Host-plant susceptibility of certain coniferous trees is compared with some other coniferous dwelling aphids.

**S22.4.** A COMPARATIVE STUDY OF MORPHOLOGICAL VARIATION AND FINE STRUCTURE OF  
**1** SOME HEAD ORGANS IN DYTISCID LARVAE (COLEOPTERA)

LUIGI DE MARZO<sup>1</sup> and ANDERS N. NILSSON<sup>2</sup>. <sup>1</sup>Inst. Entomol. Agraria, via Amendola  
165/A, 70126 Bari, Italy. <sup>2</sup>Dept. Ecol. Zool., Univ., S-90187 Umeå, Sweden.

A survey, including not previously published data, is given of the comparative morphology and fine structure of the following head structures of dytiscid larvae: clypeal setae, glandular organs of epipharynx, pubescent area of the cibarial ceiling, cibarial closing, premaxillary lobes, sensillum of the third antennal segment, and mandibular grooves.

The evolutionary trends found in these structures are discussed.

**S22.4.** Comparative studies on the musculature of the labium and  
**2** metathorax of adult Hydradephaga and some Carabidae

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Universität Tübingen Lehrstuhl für Zoologie D-74 Tübingen

The labial muscles in Gyrinidae, Noterus and some Carabidae rise from a characteristic central apodeme situated in the submentum. The dorsal muscle of the labium is reduced in Noterus and Gyrinidae. In the metathorax, a large number of muscles (9) is reduced in Gyrinidae as in Noterus. These results point to a sistergroup relationship of Noteridae and Gyrinidae.



**522.4.** ASSOCIATION ANALYSIS OF WATER-BEETLE COMMUNITIES  
**4** (COLEOPTERA: DYTISCIDAE ET HALIPLIDAE)

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Quantitative samples of water-beetles inhabiting stagnant waters had been taken 1978 and 79 in different localities of Southern Germany. About sixty environmental factors on physical, chemical and structural aspects of each sampling-site had been stated.

By means of association analysis connections between species and relations to their environment are isolated. Elements of community structure of both water-beetle families will be shown.

**522.4.** ZOOGEOGRAPHY AND ECOLOGY OF THE DYTISCIDAE OF THE NEAR EAST  
**5**

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About 70 species of Dytiscidae are known from countries of the Near East. The Dytiscidae fauna of Israel and the Sinai are explored best while less data are available from Jordan, Syria and Lebanon. Ecological data are presented for most of the species. Five zoogeographical regions or subregions (Mediterranean-, Irano-Turanian, Saharo-Arabian and Euro-Siberian subregion and Ethiopian region) are extending into the Near East. Species found in this area are referred to the above classifications and their distribution within the Near East is evaluated.

522.4. CHARACTER SELECTING FOR CLADISTIC PURPOSES IN SUPRASPECIFIC UNITS  
6 WITHIN HYDRADEPHAGA (COL.).

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Supraspecific system of Hydradephaga did not yet receive a cladistic approach; intuitively the general layout should not be significantly modified by such a treatment, but specialists should seriously start investigating on plesiomorphies, apomorphies, symplesiomorphies and synapomorphies and to establish how far Hydradephaga as a whole can be regarded as a monophyletic group (CROWSON 1960) or if BURMEISTER's (1976) and BAEHR's (1979) views have at least in part to prevail. An analysis from such an angle of all characters so far utilized by specialists for higher hydradephagan classification is herewith newly proposed (FRANCISCOLO 1979) for discussion, with some emendations, additions and comments.

522.4. A PHYLOGENETIC ASSESSMENT OF THE HYDRADEPHAGA BASED PRIMARILY ON  
7 ADULT HEAD STRUCTURE

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Characters associated with adult tentorial, antennal, mouthpart, and proventricular structure of taxa representing all families of Hydradephaga were phylogenetically analyzed. Evolution of these structures apparently has been conservative; they often varied only at the family and subfamily level. The data indicates that Amphizodae is probably the sister group to Dytiscidae. Within Dytiscidae, each subfamily, except Colymbetinae, is judged monophyletic. Laccophilinae, Dytiscinae, and some colybetines (Agabetini and Agabini) together form a monophyletic clade.

The evident and consistent differences between members of Hydradephaga at the family and subfamily level with respect to mouthpart and proventricular structure indicate that divergence in these digestive structures may have played a significant role in ecological specialization and isolation of lineages during initial stages of evolution. This hypothesis would be supported if future studies demonstrated that extant dytiscids with different digestive structures always consumed different food items.

**S22.4.** AGE STRUCTURE, PHENOLOGY AND NUTRITION OF SOME  
**9** RHEOPHILIC DYTISCIDAE (COLEOPTERA)

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Several Dytiscidae species (genera: Platambus, Oreodytes, Deronectes) from brooks of the Eifel region (western part of Germany) show a distinct irregular distribution. In order to find reasons for these discontinuities and to define possible ecological isolation mechanisms adults of some water beetle species were age classified and their phenology was studied. Contents of water beetle crops and the seasonal varying availability of prey organisms were further investigated.

Between closely allied species only minor differences with respect to age structure and phenology of the populations could be found. For all species investigated Chironomidae larvae represent the most important prey organisms which is especially evident within smaller sized beetles. Beetles characterized by a greater body size additionally prefer further kinds of food. Within a species ingestion of prey organisms was both qualitatively and quantitatively correlated with the presence and abundance of prey organisms present. Smaller water beetles were found to prefer smaller Chironomidae larvae as compared with greater sized beetles.

**S22.4.** LABORATORY CULTURE AND FLIGHT DEVELOPMENT OF THE WATER  
**10** BEETLE DYTISCUS MARGINALIS L. (COLEOPTERA, DYTISCIDAE)

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Adult beetles of Dytiscus marginalis L. were kept in aquaria which simulated their natural habitats. A single female started egg deposition in May. 30 out of 162 hatched larvae were reared to the adult stage. The main problems were to isolate even the newly hatched larvae because of their cannibalism, to procure living food during the first and second larval stage and to control fungal infections. One day after the imaginal moult flight ability of the beetles was tested on a flight balance in front of a wind tunnel. Stable flights could be induced rather easily. Following 10 min of flight, the mean wing-beat frequency is 34 Hz and the mean flight speed 2.4 m/s. Corresponding data from fully developed beetles are increased by 25%. The rise of wing-beat frequency and flight speed during imaginal development of individual beetles seems to be discontinuous.

**S22.4.**  
**11** A REVIEW OF THE SPECIES OF THE GENUS BIDESSODES Zimmerman  
(Coleoptera: Dytiscidae)

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The largely South American genus Bidessodes (Coleoptera: Dytiscidae) is composed of twenty or more described and undescribed species. All the species are superficially very similar, but can be distinguished by the structure of the male external genitalia and in some by external secondary sexual characters. Diagnoses, keys, and figures are given for the identification of the species.

**S22.4.**  
**12** EVOLUTION OF HYDRADEPHAGA (COLEOPTERA) WITH RESPECT TO HABITAT.

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Lentic habitats have been and are the major habitat of evolution of Hydradephaga because of respiratory and other constraints. Certain unrelated groups have invaded running water and other specialized habitats including terrestrial habitats. Taxa within specialized habitats are of varying phylogenetic age and position and range from old, relict stocks (e.g., Trachypachus, Amphizoa, Spanglerogyrus) groups of moderate age (e.g., Oreodytes, Geodessus) and groups which have relatively recently invaded new habitats. (e.g., certain species-groups of Agabus, Copelatus and Aglymbus).

My model of habitat evolution shows that the above constraints are overcome rarely and result in low diversity of taxa in specialized habitats. Whereas taxon pulses in lentic habitats displace phylogenetically younger groups, specialized habitats represent a "museum of evolution" of Hydradephaga.

**S22.4.** TAXONOMY AND ZOOGEOGRAPHY OF THE GENUS LACCONNECTUS MOTSCH.  
**13** (COLEOPTERA, DYTISCIDAE)

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The genus *Lacconnectus* Motsch. has been revised. A total of 35 species are recognized in South Asia, 21 of which are new. This unexpected fact can be explained by the analysis of the distribution of the different species and their particular habitats.

Species groups and the most interesting characters, such as the aedeagus and reticulation, are presented and illustrated. The validity of the two subgenera as well as the questionable occurrence of the genus in Central and South America are discussed.

**S22.4.** FOOD PREFERENCES IN LARVAL *Dytiscus* BEETLES  
**14**

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Larval dytiscid beetles of the genus *Dytiscus* are worldwide recognized as predators of amphibian tadpoles except at least two species, the neoarctic *D. harrisii* Kirby and the palearctic *D. semisulcatus* Müll, that feed preferentially on caddisfly larvae. We have experimentally investigated the problem of food preference by offering five types of prey to individuals from syntopic populations of *D. verticalis* Say and *D. harrisii* and from a distant population of *D. verticalis*. The preys were frog and toad tadpoles, two kinds of caddisfly larvae and a mosquito larvae. Differences in predatory responses between the three populations of *Dytiscus* are discussed in terms of natural prey induced preferences and food niche partitioning.

**S22.4.** THE JAPANESE DYTISCIDAE WITH SPECIAL REFERENCE TO THE NORTH  
**15** AND SOUTH ELEMENTS OF THE FAUNA

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In Japan, 90 species of Dytiscid-beetles are known at the present time. Five groups are suggested by their distribution patterns. It is mainly the northern and southern groups that are discussed. The species of the northern group mostly consists of valid species that have become isolated from the Palearctic ones and may have appeared during the Glacial Period. The southern group consists of species which are commonly distributed widely in the Oriental region and may have migrated in the postglacial times.

**S22.4.** DEVELOPMENT AND SWIMMING BEHAVIOUR OF THE WATER BEETLE  
**16** ACILIUS SULCATUS L. (DYTISCIDAE, COLEOPTERA).

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At 18 °C Acilius sulcatus needs 8 weeks for its development from egg to imago. After imaginal moult its weight is 2.1 mN, increasing in the following 2 weeks by 30%. Although the larvae are cannibalistic (depending on availability of food, i.e. Daphnia and mosquito larvae), they could be cultured in groups of about 20 individuals of the same stage. Imagines were tethered to a strain gauge and stimulated by the current of a water canal. Independent of age, the initial high values (median) of hindleg-stroke frequency (6-8 Hz) and amplitude (110-140°) of the hind-legs decrease with swimming duration (3-4 Hz, 90-120°). The swimming speed depends in tethered ('thrust-compensated' conditions), as well as in free swimming animals, more on the leg-stroke frequency than on the amplitude. In free swimming animals the frequency was about 5 Hz, the amplitude 90°, and the speed 12 cm/s (high speed filming).

S22.4.  
17

FIRST REPORT ON THE ECOLOGY OF THE PHREATIC WATER BEETLE SIETTITIA  
AVENIONENSIS GUIGNOT (COLEOPTERA DYTISCIDAE)

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After the discovery of Siettitia avenionensis in the groundwater of the Upper French Rhône (GIBERT et al, 1977 ; RICHOUX, 1978), prospection pumpings have shown the presence of larvae in the alluvial aquifer (RICHOUX 1980). The finding of a sampling site (a neglected gravel-pit) where adults and larvae are regularly collected throughout the year, has enabled us to observe the evolution of this population, its distribution and seasonal occurrence in relation to the habitat and in particular to the variations of the groundwater levels.

S22.4.  
18

LIFE HISTORY STRATEGIES OF NEARCTIC AGABINI (COLEOPTERA: DYTISCIDAE)

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We have collected 20 species of Agabus and 8 species of Ilybius in Wisconsin (northern U.S.). Because most species cannot be identified as larvae and separation of the 2 genera is not always certain, life histories must be deduced from adult records. All Ilybius apparently have similar life cycles, wintering mostly as larvae, pupating in spring or early summer, and emerging shortly thereafter. Species that develop in cold swamps emerge last. Life histories of Agabus vary widely. The 3 lotic species apparently winter both as larvae and adults, with larval development usually being completed in spring or early summer. Adults emerge mostly in autumn. Agabus ambiguus inhabits both streams and ponds, wintering as an adult in many types of habitats. It flies mostly to spring-ponds in May, and the life cycle is completed in those ponds or adjacent streams by late summer. The remaining Agabus species inhabit a variety of lentic habitats. Most winter as adults, and mate and oviposit in spring. Some winter in their breeding sites, oviposit in late March or early April, and complete larval development in mid May. Others winter in alternative lentic habitats, fly to their breeding sites in late April or May, and complete larval development by late June or July. Agabus erichsoni apparently winters mostly as an egg, enabling it to use vernal ponds for larval development, and at least one other species may winter as a larva in permanent ponds. Keys to larvae of all species are needed before life histories can be fully understood.

**22.4.** CONTRIBUTION TO FLIGHT BEHAVIOR AND FLIGHT PHYSIOLOGY OF  
**19** ADEPHAGOUS WATER BEETLES.

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Beetles of the family DYTISCIDAE fly like all the adephagous coleoptera (Cicindela-type):

forwings are held like airfoils, they do not oscillate and they are mostly supported by the two first pairs of legs. The functions of the elytra are: stabilisation of flight and support of the lift in horizontal flight.

DYTISCUS, ACILIUS and RHANTUS fly seldom, but over long distances. Flight control (reaction on airstreams and on light), vertical change of direction are discussed in respect to wingbeat frequency and wing beat amplitude. Some data about kinematics of the alae are added.

15 min.

**22.4.** ON THE PHYLOGENETIC RELATIONS WITHIN THE HYDRADEPHAGA,  
**20** ~~WXXM~~ USING LARVAL AND PUPAL CHARACTERS.

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Numerous morphological characters of larvae and pupae had been compared within the groups of Hydradephaga, and <sup>in</sup> some carabid beetles. For my approach to the "phylogenetic tree" of the Hydradephaga, which will be presented in the following, I try to use only "joint derived" characters (synapomorphies after Hennig) as the evidence for a common  $\phi$  origin. So far, few characters seem to show the monophyletic origin of the group "Trachypachidae + Hydradephaga" and of the group "Hydradephaga". The monophyly of the big group "Amphizoidae + (Hygrobiidae + (Copeladini + all the remaining Dytiscidae))" as well as their subgroups - as indicated here by parentheses - can be well proved by a lot of synapomorphic features. The sistergroup of those seems to be the remaining Hydradephagan families, i. e. the group "Gyrinidae + (Noteridae + Haliplidae)".



**S22.4.** THE INFLUENCE OF ACIDITY AND CHLORINITY ON THE DISTRIBUTION OF HYDRO-  
**21** PORUS SPECIES (COLEOPTERA; DYTISCIDAE) IN THE NETHERLANDS

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Abstract

1. Adult water beetles were collected from more than 730 localities in the Netherlands. The distribution of eighteen species of the genus Hydroporus has been related to acidity and chlorinity by use of the Index of Representation (I.R.).

2. H. tristis, H. obscurus, H. pubescens, H. gyllenhallii, H. melanarius and H. neglectus are acidobiont species in the Netherlands and acidity forms a main environmental variable in their distribution. H. scalesianus, H. memnonius and H. nigrita are acidophilous species. H. erythrocephalus, H. umbrosus and H. incognitus have a significant preference for acid waters but a wide tolerance. H. striola and H. dorsalis have a non-significant optimum for pH between 6.1 and 7.5. The very common H. palustris and H. angustatus have an optimum for pH between 6.6 and 7.5 and they avoid acid waters. H. tessellatus is the only alkaliphilous species. H. planus is indifferent with respect to acidity.

3. H. tessellatus is halophilous and chlorinity is an important environmental variable for this species. The remaining species with the exception of H. memnonius, H. nigrita, H. palustris and H. planus are haloxenous.

4. Acidity is a better parameter than chlorinity for the description of the distribution patterns of Hydroporus spp. in the Netherlands, because of a better segregation of the species.

**S22.4.** THE EFFECTS OF HUMAN ACTIVITY ON THE DISTRIBUTION  
**22** OF AQUATIC COLEOPTERA IN SOUTH EASTERN ENGLAND.

R. CARR

32 Kingsley Road, Maidstone, Kent, England.

The dispersal of aquatic coleoptera in South Eastern England is shown to be directly related to historic and modern commercial activities of man.

**S22.4.** LIFE-HISTORIES AND HABITATS OF NORTHERN EUROPEAN  
**23** AGABINI (COLEOPTERA: DYTISCIDAE)

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Life-cycles of northern European species of Agabus Leach and Ilybius Erichson are described from field and literature data. The different kinds of life-cycles found are classified on main overwintering stages into: (1) only adults, (2) adults and larvae, (3) adults and eggs, (4) only eggs. The first kind is mainly found in species of Agabus inhabiting permanent waters, where larval development is possible during the whole summer. The second kind is found in all species of Ilybius and in some Agabus species mainly inhabiting springs and springfed streams. The overwintering of eggs has evolved in some species inhabiting temporary waters where larval development takes place in spring and early summer.

**S22.4.** HYDROPORUS MELANOCEPHALUS (MARSHAM, 1802)  
**24** IN GREENLAND.

POUL CHRISTIAN JEPPESEN

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*The known geographical distribution of Hydroporus melanocephalus (Marsham, 1802) in Greenland is shown, discussed and compared with that of the other Greenlandic dytiscid beetle, Colymbetes dolobratus (Paykull, 1798). The three larval stages of H. melanocephalus are identified, figured, and described for the first time, and useful taxonomic features are pointed out.*

**S22.4.** THE RESPIRATORY ORGANS AND RESPIRATORY TECHNIQUES OF  
**25** HYDROPORUS PALUSTRIS L. (DYTISCIDAE)

MATTHIAS GILBERT

6105 OBER -RAMSTADT/MODAU, AM KREUZER 7, F.R.G.

The structure and composition of the tracheal system of *H. palustris* L. were analysed on the basis of cross sections. The results cover the structure and arrangement of the stigmata, as well as the position of certain segments of the tracheal system, e.g. on the esophagus or on muscular systems performing respiratory movements, and their functioning. These muscular systems were studied in conjunction with the clearly developed endoskeleton of the beetle, as well as the subelytral area, which, together with the tracheal system, serves as an air reservoir. Tests were performed to analyse the adaptation of the beetle's respiratory system to its aquatic environment, particularly the functioning and performance of the physical gill.

The results obtained enabled a theoretical model of the beetle's respiratory technique to be developed, which is based on and supported by the structure and position of the individual components of the tracheal system.

**S22.4.** Distribution and phenology of dytiscid beetles in characteristic  
**26** vegetal units of southern Québec.

BOURASSA, JEAN-P., LECLAIR, RAYMOND and YVES ALARIE

GOUPE DE RECHERCHE SUR LES INSECTES PIQUEURS

UNIVERSITE DU QUEBEC A TROIS-RIVIERES, QUEBEC, CANADA G9A 5H7

A three years survey of dytiscid beetles in six physiognomic sites of southern Quebec (vegetal units: *Alnus rugosa*, *Acer rubrum*, *Thuja occidentalis*, *Picea mariana*, bogs, sandpit ponds) gives a record of 50 species belonging to 13 genera. Some species appear to be characteristic of particular sites (ex.: *Acilius mediatulus* in *A. rugosa* unit) while others show a relative ubiquity (ex.: *Laccophilus maculosus*, *Liodes affinis*). Distribution pattern and phenology of the commonest species of dytiscid are discussed.

**22.4.** MORPHOMETRIC ADAPTATION OF THE GYRINUS SERICEOLIMBATUS COMPLEX IN  
**27** NEW GUINEA AND ADJACENT ISLANDS (COL. GYRINIDAE)

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Abstract

Samples from 28 New Guinean localities and from eight other islands exhibited a significant size heterogeneity for seven body characters as well as elytral reticulation patterns. The variation was much smaller within populations. Adjacent populations usually showed a good agreement in characters, but in some proximate populations a significant differentiation reflects some kind of dispersal barrier. The similarity of these populations to others of comparable altitudes, on the other hand, indicates that a portion of the morphological differentiations may be viewed as adaptations along an altitudinal cline ascribed to selection rather than to random effects. However, there were also correlations between some body characters and populations of different habitats of the same altitude. Possible evolutionary factors responsible for the selection of the body characters are discussed.

One new and closely allied species to G. sericeolimbatus was recognized from the western parts of New Guinea.

**S22.4.** COLOR PATTERNS IN AQUATIC BEETLES AS THEY MAY RELATE TO  
**28** THE PRESENCE OF CORTICOSTEROIDS

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Many aquatic beetles, especially in the deserts of southwestern United States, exhibit elaborate and repetitive color patterns. Some workers suggest the color patterns are cryptic and therefore adaptively significant. An alternative hypothesis relating to the presence of corticosteroids may suggest warning coloration is the defense mechanism. A synthesis of these ideas will be discussed as they relate to corticosteroids recently studied in the genus Thermonectus (Dytiscidae) and other southwestern United States aquatic beetles.

S22.4.  
29

COMPARISON OF DIVING BEETLES (COLEOPTERA: DYTISCIDAE) COLLECTED FROM  
ABOVE AND FROM BELOW A BEAVER (CASTOR) DAM

GEORGE SWENSON

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Collections of dytiscid water beetles were made in a flooded Carex lacustris stand situated behind an active beaver (Castor) dam. These were compared to beetles collected in a drier area situated below the same beaver dam and dominated by Carex rostrata. Much of the collection in the site above the dam was made in the shade of alder (Alnus rugosa).

S22.5. A NEW NATURAL SILK SOURCE FOR TURKEY, SATURNIA PYRI SCHIFF.  
4

ATIF ŞENGÜN, SERPİL BENSEL

University of Istanbul, Faculty of Sciences. Istanbul-Turkey

The biology and the characteristics of the cocoon and the silk of Saturnia pyri Schiff. which is assumed to be of economical importance has been investigated. This moth exists in many places of Turkey and it is not a culture race. Therefore it is resistant to several external factors and suitable for hybrid vigour experiments. Besides, it could be fed with various fruit tree leaves. Its cocoon is larger than the silkworm's.

## 22.5. ULTRASTRUCTURE OF SILK GLANDS OF NON-MULBERRY SILKWORMS

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The silk glands of the non-mulberry silkworms, Antheraea yamamai and pernyi, are typical exocrine gland designed to secrete large amounts of silk, as well as silk gland of the domesticated silkworm. The gland is divided three parts, posterior, middle, and anterior silk gland by their secretory function. During the final larval instar the glands develop rapidly, and they become maximal size at the wandering stage. At this stage the posterior silk gland become larger than the middle silk gland. The glands are composed of large cells, and the fibroin is secreted from the posterior and the sericins are from the middle silk gland. The posterior and middle silk gland cells take place the endomitosis during the larval period, and this results in highly polyploid cells. The convoluted nucleus contain numerous nucleoli. The cytoplasm of the posterior silk gland contains developed rough endoplasmic reticulum, Golgi complexes, and fibroin globules. The fibrous fibroin molecules synthesized in rough endoplasmic reticulum are transferred into Golgi complexes, fibroin globules, and enter in the gland lumen. The liquid fibroin column is composed of the spherical masses of fiber, each of these contain the elementary fibroin fibers. These spherical masses pass through the middle and anterior silk gland, and are finally formed as single cocoon filament in the spinneret. Scanning electron microscopic observations indicate the fine structural changes of the liquid silk in the lumen.

## 22.5. MECHANISM OF GREEN AND YELLOW COCOONS FORMATION BY ANTHERAEA YAMAMAI

### 6 ——— CHARACTERIZATION OF THE PIGMENTS ———

YOSHIOMI KATO<sup>1</sup> and HIROMI YAMADA<sup>2</sup>

<sup>1</sup>International Christian University and <sup>2</sup>Yakult Institute, Tokyo, Japan

In the Japanese oak silkworm Antheraea yamamai, cocoon color is determined by the light intensity during the larval stage. Green cocoons are formed under high intensity ( $\sim 4000$  lux), whereas yellow cocoons are formed under low intensity ( $< 40$  lux). Both green and yellow cocoons contained common yellow pigment(s). Green cocoons had an additional blue one. The blue pigment was chloroform-soluble, Gmelin reaction-positive, and showed a maximum absorption at 660 nm, a red fluorescence. It was identified as a biliverdin compound. The yellow pigment(s) were water-soluble, showing a maximum absorption at 410 nm. This might be pteridine compound(s). Larval blood contained the blue and the yellow pigments under any light conditions. These results suggest that the incorporation of blue pigment, but not of yellow one(s), into the silk gland needs intense light.

S22.5.  
9

ADSORPTION OF ACID DYE FOR ANTHERAEA YAMAMAI SILK YARN.

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The dyeing of Antheraea yamamai using a acid violet 5B (C.I. A. violet 49) was studied with respect to effects of dyeing time, temperature, penetration of a dye molecular and adsorption isotherms in comparison with Bombyx mori. Amount of hydrochloric acid as a model of acid dye adsorbed by Antheraea yamamai were approximately twice as much as those by Bombyx mori. It was observed that adsorption differences of acid violet 5B between Antheraea yamamai and Bombyx mori were induced, when the swelling of silk yarns were not sufficient under the conditions such as the early stage of dyeing, or the lower temperature like 40 - 50°C. From the observation of cross section, dyeing condition beyond 30 min. and 80°C was thought to be necessary for a dye molecular to penetrate in Antheraea yamamai. It was found that adsorption isotherms of acid violet 5B are well reproduced as superpositions of a Langmuir and a partition isotherms. And, affinity constants of non-ionic type adsorption were 0.586 and 0.534 for Antheraea yamamai and Bombyx mori, respectively.

S22.5.  
10

OBSERVATION OF THE CLAWS ON THE ABDOMINAL LEGS OF CERTAIN SATURNIID LARVAE.

OKUI, KAZUMITSU

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Most lepidopterous caterpillar have a certain claws on the planta as the end of their abdominal legs. According to Tanaka(1928), it's considered that these claws related to moving activity of caterpillar. Most claws are usually arranged limited to a semicircle or small arc on the inner margin of the planta. In such case, the planta itself generally became asymmetrical by a reduction or obliteration of it outer half(Snodgrass,1935). The form of claws and their arrangement differs by species, and number of claws changes in each instar. Then the author supposed that compared with the claws of closed species may be indicated to a process of species differentiation. And perhaps, will be considered the relation with their behavior, for example, the case of climbing activity.

In this report, the author carried out observation by scanning electron microscope from 1st to 3rd instar larvae of certain Saturniid insects and had been compared its.

522.5. DIAPAUSE IN THE JAPANESE OLK SILKWORM, ANTHERAEA YAMAMAI  
12

SAKATE, S and Y. KATO\*

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International Christian Univ., Mitaka, Tokyo 181, Japan\*

This wild silkworm is a univoltine species, overwinters at embryonic stage and passes a hot summer season at a state of pupal diapause.

Pupal summer diapause was regulated by a photoperiod in pupal and larval stage. O<sub>2</sub> consumption curve during pupal period was displayed as four types at least, that of diapausing pupae was about one-fifth of low level of non-diapausing one and the brainless pupae maintained a low level more than 3 months. And mechanical shaking of diapausing pupae was effective for early termination of the diapause.

Maximum peak in O<sub>2</sub> consumption of eggs had been shown on the 7th day-old after oviposition, the embryo seemed to take orally all yolk into the gut and thereafter entered to diapause condition. The diapausing embryo ligatured between head and thorax anew developed, when that was contacted with low temperature. But the one ligatured between thorax and abdomen developed only in abdomen. We have not been found satisfactory artificial hatching method for rearing two generation in a year.

522.7. INTERSPECIFIC COMPARISON OF CARABID BEETLE POPULATION SIZES BY MEANS  
1 OF PITFALL TRAPPING WITHIN ENCLOSURES.

DESENDER, K. & J.-P. MAELFAIT.

Lab. Anim. Ecol. K.L.Ledeganckstraat 35 B-9000 GENT BELGIUM.

Large scale quadrat sampling, enclosed and unfenced pitfall trapping could be compared from a heavily grazed pasture (Melle, Belgium).

Fenced pitfalls always yield much more reliable estimates, even after only a few days of trapping, showing a much closer relationship with quadrat results.

Departures from real relative abundances as found with pitfalls seem to have a biological meaning.

The former method is especially suitable for short term investigations during activity peak periods of carabid beetles.



## S22.7. EXPERIMENTAL STUDY OF VARIABLES AFFECTING YIELDS OF PITFALL TRAPPING. 2

DESENDER, K., J. MERTENS, F. BERBIERS, J. HUBLÉ, J.-P. MAELFAIT, M. POLLET & R. SEGERS.  
Lab. Anim. Ecol. K.L. Ledgenackstraat 35 B-9000 GENT BELGIUM.

The yields of three types of pitfall traps for different taxonomic groups (Araneida, Collembola, Coleoptera Carabidae, Coleoptera Staphylinidae) made in a pasture near Ghent (Belgium) were compared with quadrat results. Three types of variables were studied in different combinations, i.e. grass height (comparing grass islets surrounding cattle droppings with shortgrazed areas), diameter of the trap (comparing glass tubes with glass jars) and the presence or absence of guiding devices. The results stress the importance of comparative methodological research in pedobiological investigations.

## S22.7. Attractant trap modification and its use in estimating 3 Dacus spp. populations by multiple recapture method in a village.

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Universiti Sains Malaysia, Malaysia.

### Abstract

A modified attractant trap to capture live Dacus adults, is described. The modified traps baited with methyl eugenol (0.5 ml), were used to estimate adult male populations of Dacus dorsalis and D. umbrosus in a small village in Penang. Daily estimation of D. dorsalis during October, 1983, showed population densities between 270 and 1,000 male flies/ha (probability of survival 0.58 - 1.0). Weekly population densities were estimated during January to March, 1984, for D. dorsalis - between 720 and 1,290 male flies/ha (probability of survival 0.40 - 0.72, mean = 0.60); and for D. umbrosus - between 390 and 1,025 male flies/ha (probability of survival 0.33 - 0.86, mean = 0.63).

**P22.7.-** SOME RECOMMENDED ECOLOGICAL METHODS FOR SAMPLING, EXTRACT-  
**1** ING, PRESERVATION, STORAGE AND SHIPMENT OF SOIL ARTHRO-  
PODES.

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PLANT PROTECT. DEPT., FAC. OF AGRIC., TANTA UNIV. KAFRE EL-SHEIKH  
EGYPT.

A comparative study of the most prevalent procedures used all over the world, for the sampling and extracting soil arthropod fauna are reviewed and discussed. An advice is given whenever to use each method, for best results. Advantages and disadvantages, of each method is fully discussed. The simplest methods for permanent and temporary preservation of organisms are handled. The most recommended solutions for the preservation, clearing and mounting specimens are recorded and discussed.

The storage of specimens in laboratory and museum is included within the article. Shipment of slides and vials are reviewed with the author's recommendations. The article, fully covers most of the mentioned methods with the necessary simplified figures.

**P22.7.-** DOMINANCE STRUCTURES OF EPIGAEIC INSECT POPULATIONS REGI-  
**2** STRATED BOTH BY PITFALL-TRAPS AND KEMPSON-EXTRACTION

MELBER, Albert

Lehrgeb. Zoologie-Entomologie, Universität, D-3000 Hannover 21

In the same biotope (sandy Calluna-heathlands in north-western Germany) groundbeetles (Col., Carabidae) and epigaeic bugs (Het., Lygaeidae, Reduviidae, Tingidae) were quantified by two different methods: registration of activity-density by modified BARBER-traps and estimation of actual population-density based on data from KEMPSON-extractions. The investigations were performed over several years. The results of the two methods employed were compared with regard to the different dominance structures. Factors are discussed which lead to under- or over-representation of certain species in pitfall-trap-catches compared with the actual population-density during the course of the year. Correlations between activity-density and population-density are discussed.

**S22.8.** RELATIONSHIPS OF PALEARCTIC AND NEARCTIC GENERA OF ALTICINAE  
**1** (COLEOPTERA: CHRYSOMELIDAE)

DAVID G. FURTH DIVISION OF ENTOMOLOGY; PEABODY MUSEUM;  
YALE UNIVERSITY; NEW HAVEN, CT USA

Study of the approximately 30 Palearctic and 45 Nearctic genera of Alticinae reveals some relationships previously undetected. Examination of external and internal morphology, including the genitalia and the metafemoral spring, indicate synonymy of a few Palearctic and Nearctic genera that are actually true Holarctic genera. Further parallels of food plant ecology and zoogeographic patterns are useful in evaluation of these relationships. Possible scenarios of the historical biogeography of Palearctic and Nearctic Alticinae are given with speculation on connections to other faunal regions.

**S22.8.** ON THE PHYLOGENY OF THE CRIOCERINAE (COL. CHRYSOMELIDAE)  
**3**

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D-7800 Freiburg, FRG

A phylogenetic analysis according to HENNIG proved that the Sagrinae are the sister-group of the Criocerinae, whereas the Donaciinae are sister-group to both. The autapomorphies of the Sagrinae are: processus between the fore coxae broad and prominent, galli-cole larvae; the autapomorphies of the Criocerinae: stridulation apparatus elythro-abdominal on the 7th tergite, larval labrum with 3 pairs of labral setae, larval anus dorsal, larval segments 1-8 with ambulatory warts; autapomorphies of the Donaciinae: aquatic life, larval spiracula of the 8th segment projecting like a pair of spurs. Synapomorphy of Sagrinae+Criocerinae: crossed frontal grooves extended into postocular sulci; synapomorphy of Sagrinae+Criocerinae+Donaciinae: manubrium formed as vertical plate. This latter taxon can be called "Crioceriformes" (MONROS). However, it was not possible to find characters which could support the membership of the Megalopodinae, the Orsodacninae, or the Bruchidae to this taxon. Similarities between these groups and certain "Crioceriformes" can be shown either as plesiomorphies or as convergencies.

**522.8.** Systematics and Ecology - an Attempt of Correlation in Leaf  
**5** Beetles ( Coleoptera: Chrysomelidae )

WALTER R. STEINHAUSEN

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An attempt is made to correlate systematics and ecology of some groups of leaf beetles. The determination keys of adults and larvae are compared with the arrangement of the plant families respectively. Only groups with numerous species and a sufficient number of known larvae are suitable for this comparison. The subfamily Chrysomelinae, and the genera *Cryptocephalus* Geoffr., *Chrysolina* Motsch. and *Cassida* Lin. are used for this purpose. There are different confirmations between the keys of adults and larvae and the groups of plant families respectively. Within the arrangement of species in a genus too less larvae are still known to obtain a definite statement.

**522.8.** Genitalia, Taxonomy, & Distribution of Nearctic  
**6** Plateumaris (Coleoptera:Chrysomelidae)

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Donaciinae is a virtually cosmopolitan group, consisting of 5 - 9 genera (depending on authors). The genus Plateumaris is not well defined and its relationships to other Donaciinae are unclear. As presently conceived the genus includes 16 nearctic species (about 34 world-wide). Most nearctic species belong in the subgenus Euplateumaris. Distribution patterns show full-glacial displacement southwards, as evidenced by relictual southern higher-altitude populations. Populations isolated in eastern and western refugia during the Pleistocene have diverged slightly and complete introgression is prevented by a mid-continental grassland barrier. Eastern North America shows a relatively great degree of endemism, while only one variable species is limited to the western cordillera. Structure of the endophallus (internal sac) is mostly species-specific; it is also a useful character system for determining species-groups. Other genitalic characters are potentially useful at generic and subgeneric levels. Revisionary work on world species of Plateumaris and other genera is being done based on genitalia. Phylogenetic reconstruction cannot be accomplished without consideration of the world fauna. The nearctic fauna of Plateumaris is composed of several species-groups whose sister-taxa occur in other regions.

**522.8.** *Phaedon fulvescens* : A possible control agent of *Rubus*  
**7** in the Tropics.

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In the Mascareignes and Madagascar, two *Rubus* species have been introduced : *Rubus moluccanus* and *R. alceaefolius* or possibly an hybrid of both. The original species have been imported deliberately from the Vietnamese Highlands and are actually a pest devastating pasture areas.

After analysing the natural enemies of *Rubus* in the Tam Dao Highlands (1500 m) in North Vietnam, I selected several fungi, mostly rusts, and some Coleoptera, of which only few Chrysomelidae seem entirely selective, i.e. not attacking roses and strawberries as other beetles do. There are several species of *Chlamisus*, *Basilepta*, *Pseudoliprus*, but mostly *Phaedon fulvescens* seem the ideal species to be imported overseas, because it shows no diapause, it has several generations per year and develops quick (15 days). The eggs are deposited in the stipules and the larva is well protected by 9 exertile glands.

**522.8.** OBSERVATIONS ON OREINA SUBG. PROTORINA IN THE ALPS  
**8**

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The subgenus Protorina is a group of zoogeographical interest, spread over the Alps and other European mountain ranges. In the Alps it is climbing up to altitudes of 3000 m and is adapted well to the extreme living conditions in these regions. So the species of Protorina show a high resistance against low temperatures and moisture; they avoid daylight and sunshine. The females deposit only one or a few larvae at the host plant, in this way an optimal larvae density is guaranteed. The larvae have to seek suitable hiding places in the same active way as the adults do.

## 522.8. OVERWINTERING OF FLEA BEETLE PESTS OF RAPESEED CROPS IN WESTERN CANADA

9

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Phyllotreta cruciferae (Goeze) and Phyllotreta striolata (F.) (= vittata (F.)) are pests of rapeseed crops in western Canada. Overwintered adults attack seedling rapeseed crops in the spring. Both beetles have a single generation per year, with the new generation of adults appearing in late summer. These adults feed, and then move into bushy fencerows, hedgerows and groves of trees, where they will overwinter in leaf litter and turf beneath the snow. Winter temperatures in these overwintering microhabitats are usually between  $-1$  and  $-8^{\circ}\text{C}$ , even when air temperatures are much lower. Winter survival of beetles is usually high. Sampling showed combined mean densities of over 3 million flea beetles per hectare overwintering in a grove of trees in one winter. Within the grove, both species of beetle showed an aggregated rather than a random distribution, and thus many samples are required to obtain a reliable estimate of the numbers of overwintering beetles present.

## 522.8. ATTRACTION OF ALTICINAE TO PYRROLIZIDINE ALKALOIDS

10

MICHAEL BOPPRÉ

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Several species of Alticinae (Col.: Chrysomelidae), particularly of the genus Gabonia, were recorded to be attracted to withered plants containing pyrrolizidine alkaloids (PAs) as well as to pure PAs exposed in the field in Kenya/East Africa. This behaviour parallels the habits of various Lepidoptera which utilize PAs as precursors for male pheromones and store them. The function(s) of PAs ingested by the beetles remains in question, however, male-limited attraction is indicative for a role concerned with reproductive behaviour. — Possibly, the pharmacophagous association of Alticinae to PAs is an ecological character relevant to taxonomy, too.

**S22.8.** POPULATION DENSITY OF THE COLORADO BEETLE IN BULGARIA  
**11** AND MODERN SYSTEMS FOR ITS CONTROL

DR ANTONIA MATEEVA-RADEVA

"V.Kolarov" Higher Institute of Agriculture - Plovdiv

During the past two decades the Colorado beetle - *Leptinotarsa decemlineata* Say was recorded as the economically most important pest of potatoes, eggplants, and tomatoes in our country.

The object of our study was to establish the reasons for the great variations in the population density and harmfulness of this pest for a long period of time as related to the ecological conditions of Bulgaria.

In addition to that they are pointed out the elements of the modern systems for controlling this pest in the separate crops

On the basis of the economic estimation specific control treatments are recommended for the separate regions.

**S22.8.** SEPARATE NICHES FOR TWO SPECIES OF ASPIDOMORPHA (COLEOPTERA,  
**12** CHRYSOMELIDAE) LIVING ON IPOMOEA FISTULOSA M. & DE BARRY

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R. K. SHRIVASTAVA Dept. of Zoology, Government Arts & Science College, DURG, M.P.  
491001 India

Two species of Aspidomorpha, A. militaris and A. sanctae-crucis live on leaves of the same host plant, Ipomoea fistulosa. Their active periods are similar. They are, however adapted to different niches. A. sanctae-crucis adults feed mostly on marginal portions of leaves, while adults of A. militaris on submarginal parts. A. militaris is found in more humid situations, and A. sanctae-crucis in comparatively dry locations. Larval habits of the two species also differ. This case is a good illustration of the Gause's Principle.

**522.8.**  
**13** ADAPTATION OF CHRYSOMELIDAE TO SOLANACEAE

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Solanaceae is a cosmopolitan family with over 2,000 species. It contains many economic important vegetables and fruits such as potatoes, tomatoes, eggplants, chillies, paprika, and peppers. Many species of this family are indigenous to the Neotropical and Nearctic regions. Surprisingly few chrysomelids are solanaceous feeders, occurring sporadically in the subfamilies Alticinae, Cassidinae, Chrysomelinae, Clytrinae, Criocerinae, Eumolpinae, and Galerucinae. Most of these solanaceous feeders are of Nearctic and Neotropical origin, suggesting a long association of these insects with their hosts. The host specificity of eight species of the genus Leptinotarsa is used to illustrate the mode of ecological, physiological, and behavioral adaptation of chrysomelids to Solanaceae. Host selection by these beetles is determined by the qualitative and quantitative differences in various solanaceous alkaloids. Steroidal glycoalkaloids have been shown to act as the most potent deterrents against several species. Available evidence thus far accumulated suggests that coevolutionary interactions between Solanaceae and Chrysomelidae have been minimal. Because of its inherent effective defense system, Solanaceae has been well protected from herbivores. To surmount the chemical defenses of Solanaceae, chrysomelids would have to evolve specific adaptive mechanisms.

**522.8.**  
**15** DIFFERENCES BETWEEN THE FORMER AND THE PRESENT DISTRIBUTION OF CHRYSOMELIDS IN WESTFALIA (COLEOPTERA, CHRYSOMELIDAE).

KROKER, HANS

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55 of the 196 chrysomelid species (except Alticinae) reported for Westfalia disappeared until 1950, only 3 species are new. Many others show a decline of their population density, some disappeared in parts of the country. Possible reasons for the disappearance or the decline are discussed.



**S22.8.**  
**16**

THE EVOLUTIONARY BIOLOGY AND TAXONOMY OF THE AUSTRALIAN EUCALYPTUS  
BEETLES

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Approximately 200 species of paropsine eucalyptus beetles have been described from Australia associated with some 600 species of eucalypts. The adults are peculiarly difficult to identify after death but are readily recognised when alive by colour and habits. The larvae are as diverse as the adults are similar. This diversity of characters is associated with an equal diversity of habits. Their present evolution appears to be rapid and to parallel that of other unrelated chrysomelid groups on other continents.

**S22.8.**  
**17**

THE EFFECT OF GROUP SIZE ON LARVAL GROWTH AND SURVIVORSHIP  
IN PLAGIODERA VERSICOLORA

BREDEN, FELIX AND MICHAEL J. WADE. DIVISION OF BIOLOGICAL SCIENCES, UNIVERSITY OF MISSOURI, COLUMBIA, MO. AND DEPARTMENT OF BIOLOGY, UNIVERSITY OF CHICAGO, CHICAGO, IL., USA

The larvae of Plagiodera versicolora remain in groups of full and half sibs during the early stages of development, feeding on leaves in a coordinated fashion and exuding an anti-predator chemical when disturbed. The survivorship of naturally occurring groups of larvae was studied during four seasons between 1979 and 1983. In 3 of 4 years there was a significantly positive effect of initial group size on larval survivorship. An experimental study in which initial groups of 2 to 10 larvae were formed and sampled from 1 to 6 days after hatching showed that small groups grew much more slowly than larvae in moderately sized groups. Controlled breeding studies in the laboratory and the field showed genetic variance for the traits controlling larval group size, including cannibalism rate and clutch size.

W22.9.  
1

## GALL-MIDGES IN AGRICULTURE

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The harmful and beneficial effects of Cecidomyiidae on agricultural production will be reviewed on a world basis with emphasis on major crop pests and on species that are actual or potential agents for biocontrol of aphids, mites and other pests or of weeds.

W22.9.  
2

## THE TRANSLOCATION OF PARASITES OF THE THECODIPLOSIS JAPONENSIS

KO, J.H., Park K.N., & B.Y. Lee  
(Forest Research Institute, Seoul, Korea)

Inostemma seoulis, Inostemma hockpari and Platygaster matsutama are important indigenous species of parasites of the pine gall midge in Korea, and for several years they have been translocated from areas with high parasitization levels to areas with low parasitization levels. This was accomplished by allowing the adult parasites to emerge in an insectory, collecting them in special containers, and transporting them to the release sites.

The biologies of the parasites were studied in detail, and data were collected on settlement rates following translocation. Settlement rates varied geographically. Annual surveys indicate that parasitization levels increase until homeostasis is reached about 5 or 6 years following initial infestation.

**W22.9.** GALL-MIDGE /CECIDOMYIIDAE, DIPTERA/ PESTS IN SEEDS AND  
**3** CONES OF CONIFEROUS TREES IN POLAND

SKRZYPCZYŃSKA, M.,

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The studies on insects damaging seeds and cones of fir /A/-*Abies alba* Mill., spruce /P/ - *Picea abies*/Karst./ and larch /L/-*Larix decidua* Mill. were conducted in the Beskid Sądecki region of Poland during the period from 1976-1981. From the family Cecidomyiidae the following seminiphagous species were obtained: *Resseliella piceae* Seitn./from A/; *Resseliella skuhravyorum* Skrzypcz./from L/; *Plemeliella abietina* Seitn., *Kaltenbachiola strobi* /Winn./, *Thomasiniana ingraca* Mamajev and *Dasyneura* sp./from P/. Besides, the following saprophagous insects were collected: *Asynapta strobi* /Kieff./ /from L,P/, *Camptomyia* sp. /from A,P/, *Clinodiplosis cilicrus* /Kieff./ /from P/. Predatory species was *Lesnodiplosis holstei* Kieff./from A,L,P/. A domination coefficient and species diversity index for insects in coenotic groups were calculated. An economic significance was determined.

**W22.9.** MONITORING THE SPATIAL AND TEMPORAL DISTRIBUTION OF THE PEA MIDGE,  
**4** CONTARINIA PISI.

C. WALL<sup>1</sup>, D.G. GARTHWAITE<sup>1</sup>, N. MORRIS<sup>1</sup>, C.R. OWEN<sup>2</sup> & D.M. STURGEON<sup>1</sup>

1. Rothamsted Experimental Station, Harpenden, Herts, U.K.

2. Department of Agriculture & Horticulture, The University, Reading, Berks, U.K.

The effects of trap design and placement on the efficiency with which the spatial and temporal distribution of the pea midge, Contarinia pisi Winn. can be monitored are described.

First generation males were caught only in traps placed below crop height (wheat) in emergence sites. First generation females were caught at crop height in emergence sites and within the pea crop after immigration.

The implications of the absence of any migration of first generation males in pea crops for monitoring with pheromone traps is discussed.

W22.9. LIFE HISTORY STRATEGIES OF GALL MIDGES, WITH SPECIAL  
7 REFERENCE TO UNIVOLTINE GALL-MAKING SPECIES

JUNICHI YUKAWA

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Kagoshima University, Kagoshima-shi, 890 Japan

The pattern of life history of univoltine gall midges is divided into two main types which have further subdivisions. Type I is designated for the pattern in which mature larvae leave the host plants and then go into the soil to hibernate. In type II, immature or mature larvae overwinter in the galls on the host plants. Pupation takes place inside the galls in the following spring. A comparison is made between the two types concerning the following aspects: systematic positions of gall midges and their host plants; ecological characters of the host plants; position, shape and development of the galls; parasitoid communities; pattern of prolonged diapause; mortality factors; and other ecological or behavioral attributes of gall midges.

W22.9. BIOLOGY , ECOLOGY AND SOME MORPHOLOGICAL DETAILS ( OVIPO-  
8 SITOR ) OF COASTAL GALL MIDGES.

HANS MEYER Zoologisches Inst.Universität Kiel,Olshausenstr.40-  
60 D - 23 Kiel 1 ,Abt.Angewandte Ökologie/Küstenforschung

Coastal gall midges showed a distinct zonation of indigeneous species in salt marshes:Puccinellietum 24,Festucetum 46,seadikes - Lolio-Cynusoretum-58 species. 9 frequent species obtained maximum abundances on seadikes, 3 species in saltmarshes.Most of the coastal gall midges showed maximum abundances during July and August and maximum number of species in August.6 phytophagous species were recorded in saltmarshes (3 were restricted to halophytes)and 14 on seadikes.Especially 3 mycetophagous species showed distinct immigrations from seadikes and polderareas into the saltmarshes. The construction of the ovipositor of phytophagous gall midges showed different degrees of development referring to both the type of telescope-ovipositor (long,medium,short) and the cuticular construction of the ovipositor wall(8 th Segment) which relieves the retraction or protrusion of the ovipositor(9th segm.).

W22.9. 9 THE APPARENCE AND THE EVOLUTION OF GALLMIDGES'S GALLES

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România

ABSTRACT

Galls ar cecidias are vegetable formationa developed as a result of the relationships between the plants and the gall inducing organism in close correlation with another ecological agents.

Galmidges like the another gall inducing organisms present a degree of the galls's form from the simple one which depends on the tissues of the attempted organ, to the new forms which are high qualified.

W22.9. 12 CLASSIFICATORY CONSIDERATIONS RELATED TO DASINEURA RONDANI  
AND ALLIED GENERA (CECIDOMYIIDAE: OLIGOTROPHINI)

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On the basis of comprehensive examinations characters commonly used for the delimitation of certain Oligotrophine genera erected or accepted by Rübsaamen, all of them closely related to Dasineura Rondani, are critically reviewed. It is concluded that the generic status is in several cases not valid. As a consequence a wider concept of Dasineura is proposed. The phyletic content of Dasineura and allied taxa is discussed.

W22.9. PROBLEMS IN THE CLASSIFICATION OF THE PHYTOPHAGOUS CECIDOMYIID  
13 (DIPTERA: CECIDOMYIIDAE)

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SYSTEMATIC ENTOMOLOGY LABORATORY, USDA, C/O USNM, WASHINGTON, DC 20560

Evidence for the monophyly of phytophagous gall midges of the Supertribe Cecidomyiidi is outlined. Within this context examples are shown of taxa that bridge the gaps between genera and frustrate attempts to form a stable classification. Although the present classification is generally useful, it is evidently not entirely natural, being based partly on superficial characters. Because we still know relatively little about phytophagous Cecidomyiidi, it will be some time before we know the limits of the genera. A solution is to use broad definitions of genera while using subgenera to block off seemingly natural groups. Advantages will include nomenclatural stability and better scientific communication.

W22.9. HOST PLANTS OF *DASINEURA* (DIPTERA: CECIDOMYIIDAE): A STUDY IN CO-  
14 EVOLUTION

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DIV. OF SYSTEMATICS AND EVOLUTIONARY BIOLOGY - UNIV. OF LEIDEN NETHERLANDS

*Dasineura*, with about 180 described species, is the largest genus of gall midges. Apart from a few inquilines, these cecidomyiids are phytophagous. The majority causes galls in mainly vegetative plant tissues. An analysis has been performed on the larval morphology of about 30 species. The forms on Rosaceae and Papilionaceae appeared to be coherent groups, whereas forms on Compositae could be subdivided in two groups. This interim result may be promising in revealing the radiation of a difficult group of gall midges which possess an important position in gall midge phylogeny.

W22.9. THE MORPHOLOGY OF ANTENNAL SENSILLA IN THE PEA MIDGE, CONTARINIA PISI.  
16

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The structure and distribution of two types of sensillum on the antenna of the pea midge, Contarinia pisi Winn., are described. In the male the characteristic circumfila consist of a series of bifurcate hairs the tips of which are joined to form loops. There are two circumfila on each segment, within which the bifurcate hairs alternate with long, un-branched hairs. The distal end of each of the latter is held in contact with the extremity of the loop formed by the two adjacent bifurcate hairs.

In the female the branched sensilla lie close to the surface. The un-branched hairs, which are similar to those in the male, are not associated with the branched sensilla, but distributed over the whole surface of each segment.

W22.9. MORPHOLOGICAL ADAPTATIONS OF THE HEAD AND MOUTH PARTS  
17 OF SOME CECIDOMYIIDAE LARVAE TO THEIR FEEDING BEHAVIOUR.

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Abstract

The head of Cecidomyiidae larvae is very small and looks designed to perform only functions such as searching out and taking in food. The general head shape, leading cephalic structures like hypostomal bridge, genae, postocciput, and especially mandibles have been investigated in Cecidomyiinae larvae belonging to three different ecological groups: phytophagous (*Neolasioptera Martelli* Nijveldt, *Jaapiella medicaginis* Rübs., *Monarthropalpus buxi* Laboulb.); Mycophagous (*Prolasioptera berlesiana* Paoli, *Mycodiplosis erysiphes* Rübs., *M. tremulae* Kieff.); Zoophagous (*Dicrodiplosis pseudococchi* Felt., *Aphidoletes aphidimyza* Rond., *Therodiplosis persicae* Kieff.). All of these species clearly show the above mentioned structures close connected with the food nature and feeding habit of the respective larvae.

**P22.9.-** DIFFERENTIAL OVIPOSITION BEHAVIOUR OF DASINEURA BRASSICAE WINN. (DIPT.:  
**1** CECIDOMYIIDAE) ON A HIGH- COMPARED TO A LOW-QUALITY BRASSICA HOST

INGER AHMAN

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There are numerous reports where unequal egg distributions between host plant species or varieties have been referred to insect oviposition "preferences". However, few have investigated how such egg distribution patterns are generated by means of differences in female responses to host plants. The present study compares the oviposition behaviour of Dasineura brassicae on a "preferred" host, Brassica napus, to that on a "non-preferred", Tess suitable host for larval growth, B. juncea.

No elements of the D. brassicae oviposition behaviour were found to be unique for females on either of the two plant species. However, in total, the number of females alighting on B. napus was significantly higher than on B. juncea, indicating differences in olfactory and/or visual stimuli from the plants. Proportion of alighted females that oviposited did not differ significantly between the two plant species, but proportion of alighted females laying more than one egg batch was significantly higher on B. napus. Egg batch size was similar on the two plant species.

**S22.10.** BIOLOGY AND BEHAVIOR OF FIELD POPULATIONS OF BLATTA ORIENTALIS  
**1**

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The oriental cockroach, Blatta orientalis L., is a common pest inside and outside of houses and buildings in temperate and subtropical regions of the world. In spite of its pest status, very few studies have investigated the biology of outdoor populations.

The concrete perimeter of three large apartment buildings in Roanoke, VA, (USA) were used as study sites in 1982 and 1983. Investigations were conducted on movement, feeding, courtship, overwintering and survival. The predators and parasites associated with the population were monitored, especially the evaniid, Prosevania punctata.

Results include information on the movement of adults and nymphs from harborages to feeding sites, and dispersal of adults in the habitat. During the 6-8 hr nocturnal activity period the adults are most active during the first part, the nymphs during the later. Adults and large nymphs move 5 to 10 meters in search of food. Adults displayed limited dispersal behavior, rarely dispersing more than 20 meters from their harborage. Adults and nymphs display a wide range of feeding preferences. Small pieces of food are fought over by adults and nymphs and frequently carried away to the harborage. Preferred food included fruit and potatoes; however, adults and nymphs were also observed feeding on green and dead vegetation. Preliminary studies indicate that the overwintering population is composed primarily of nymphs. The evaniid, P. punctata was most commonly found inside the buildings.



S22.10.

2

## COCKROACH BEHAVIORAL ECOLOGY

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Cockroach behavior and reproduction have been relatively well studied in the laboratory, although investigations have been mainly limited to a few species. As our knowledge of cockroach ecology increases it is interesting to explain behavioral and reproductive adaptations, discovered in the laboratory, in terms of environmental constraints and taxonomic relationship.

Female "calling" and release of volatile sex pheromones may correlate with intersexual vertical distribution of cockroaches in forest habitats. Males of species in which females secrete non-volatile sex pheromones engage in local search when pheromone is perceived. Resource aggregations may facilitate mate-finding in some species.

Oviparous species generally occur in the least predictable environments, experience high immature mortality and have poorly developed parental/social behavior. Ovoviviparous species inhabit more predictable environments (caves, logs), competition is more intense, and parental/social behavior is more advanced. Competition among males may select for early recognition of females, material contribution to females and young, control of resources and aggressive behavior.

Ecological and behavioral characters seem to be more correlated with habitat types than with taxonomic relationship.

S22.10.

3

## INSECTICIDE RESISTANCE TESTING FOR BLATTELLA GERMANICA (L.)

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Chemical control has always been the predominant strategy for reducing infestations of the German cockroach, Blattella germanica (L.). This has led to the expression of varying levels of resistance and cross-resistance in German cockroach populations to the commonly used carbamate and organophosphate insecticides. There are many different resistance testing procedures used in the laboratory. The relationship between these procedures has been examined. The relationship between laboratory generated resistance data and actual control in the field has also been examined.

**S22.10.**  
**4** THE BEHAVIOUR OF THE ORIENTAL COCKROACH (*BLATTA ORIENTALIS* L.)

FUCHS. M.E.A.<sup>1</sup>; DENZER, D.<sup>2</sup>

1) Ernst-Rodenwaldt-Institut, Koblenz

2) Zoologisches Institut der Univ., Bonn

By means of an experimental system comprising air-conditioned chambers for environmental simulation, sensor electronics and data processing units the following behavioural parameters are determined: Diurnal rhythm in relation to nymphal stages, sex, temperature, air humidity, light and dark periods; level and amount of activity, returning to harbourages and activity range in relation to population density and duration of stay in the infested room.

**S22.10.**  
**5** A CONTRIBUTION TO THE UNDERSTANDING OF POPULATION BEHAVIOR OF BLATTELLA GERMANICA

MARY H. ROSS, Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA

The German cockroach, Blattella germanica (L.), produces an aggregation pheromone, a non-volatile sex pheromone, and a repellent. An experiment using mixed age groups showed the influence of these chemical stimuli on within-harborage aggregation, but group behavior was complex. The responses underlying these complexities are now better understood. Experiments with three nymphal age classes, adult males, gravid (egg case bearing) females, and non-gravid females show that each type tested differs in its response to filter papers exposed to low densities of adult females (presumably responses to aggregation pheromone). The intensity of the attraction differs, and also variations occur in respect to preference for paper exposed to gravid vs non-gravid females. Papers exposed to high densities of adult females are repellent, but again responses vary with age class and adult sex. Female-produced chemical cues that govern these behaviors vary with female density and reproductive state. These findings are discussed in relation to overall group behavior and the evolution of behavioral patterns that appear to be well suited to enhance species survival.

**\$22.10.**  
**6**

ANTENNAL MOVEMENTS IN THE COCKROACH PERIPLANETA AMERICANA

MARY McCOY

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This research examined movement patterns of the flagella of male Periplaneta americana, with the objective of determining how critical the antennal position is to the reception of biologically relevant information. Antennal movements were filmed from the anterior aspect of the animals, and the film images were then projected so that the relative positions of the flagella and front tarsi could be digitized. These data were entered into a computer, and were translated into Cartesian and polar coordinates for analysis. The flagella patterns occurring during pauses, forward locomotion, and turning were examined and compared. Analysis showed that the antennae move in specific temporal and spatial patterns which are correlated to the type of locomotory activity occurring. The relationship of the antennal movement patterns to the acquisition of environmental information by the antennae will be discussed.

**\$22.10.**  
**7**

THE FUNCTION OF SEX PHEROMONE COMPONENTS IN PERIPLANETA  
(DICTYOPTERA; BLATTIDAE)

GÜNTER SEELINGER

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Behavioral effects of 2 pheromone components from *P. americana* females, periplanone-A (PA) and periplanone-B (PB), on conspecific males and on males of related species were investigated. Both components release upwind flight, upwind running and orientation along a gradient in conspecific males. Studies on female emission rate, relative effectiveness, behavioral adaptation and orientation patterns indicate that PB functions as a distance attractant while PA has close-range effects on orientation. Additional chemical contact stimuli are necessary for courtship release. Interspecific action of these components could be demonstrated for other PERIPLANETA species. Males of *P. australasiae* are very sensitive to PA, but PB inhibits the response to PA in this species.

# Supplements

55.1.  
43

Adipokinetic hormone, lipoproteins, and apoproteins in Locusta

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In locusts, adipokinetic hormones (AKH) have well documented effects on haemolymph lipid levels; they act on fatbody lipid stores to release diacylglycerols which are loaded onto acceptor lipoproteins. As a result of this loading of lipid, small apoproteins ( $C_L$ -proteins) bind to the lipoproteins during the formation of  $A^+$ . An assay utilizing a heparin-EDTA precipitation technique has enabled  $C_L$ -proteins to be measured directly and studied in individual locusts (before, the resting state, and 90 min after AKH injection, the elevated state) at various ages before and after the imaginal ecdysis. The  $C_L$ -protein concentration reaches a peak 14 days after the imaginal ecdysis. After AKH injection into 14-day-old males, there is a gradual decrease in free  $C_L$ -proteins in the haemolymph for up to 90 min (60% of total  $C_L$ -proteins are bound to lipoproteins). The levels of free  $C_L$ -proteins return to their resting values as the AKH response declines. These data support our model for the formation of  $A^+$  lipoprotein.

R9.1.  
14

ANTENNAL RESPONSE TO PHYSICAL AND CHEMICAL STIMULI AMONG THE  
PYRALIDAE CHILO PARTELLUS, MARUCA TESTULALIS AND ELDANA SACCHARINA

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On the antenna of the Pyralidae, Chilo partellus, Eldana saccharina and Maruca testulalis, sensilla styloconica occur at the antennal tips and the distal ventral ends of several antennal segments. Ultrathin sections have revealed that each styloconic sensillum is innervated by a pair of lamellated cells and single cell recordings have confirmed that at least one of these cells is a cold receptor.

The ongoing investigations using single cell and electro-antennogram (EAG) techniques are designed to find out whether the antennal sensilla detect differences in the odour stimuli emanating from the susceptible and resistant cultivars of the host plants. Results obtained with regard to Chilo partellus will be discussed.

## **R11.1.** **6** HABITAT CONSERVATION SURVEYS - A QUANTITATIVE APPROACH

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34 ROUNTON ROAD,  
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The objectives of conservation are still the subject of much debate. The many parameters taken as reasons to conserve create confusion in a difficult and emotive subject.

This paper presents a brief survey of the current objectives of conservation, a discussion of the criteria of conservation value, and suggests that the prime consideration for the conservation of a particular parcel of habitat must lie in its being shown to be the most representative habitat amongst other in and for that area.

Invertebrate faunas, with few exceptions, do not receive the consideration in conservation terms that their importance in the general welfare of any habitat warrants. Yet this group is not only more numerous at species level but often more specialized in habitat than other biological groups, and so may offer to the investigator an highly sophisticated and sensitive method of habitat assessment. Therefore, the accurate survey of the invertebrate fauna should be a central necessity performed with scientific precision instead of what is frequently a peripheral and anecdotal exercise.

A scheme is proposed for the Quantitative Replicate Sampling of sites based on species diversity applying a statistically-evaluated trapping system, the returns from which may be used to assess similar sites against a Standard Reference site.

## **R11.2.** **6** To the status of the blister beetles (Coloeptera, Meloidae) in Southern Germany

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Bannwaldallee 32, D 7500 Karlsruhe

In Germany, since 1980 all species of the genus *Meloe* are protected by law. The decline of all *Meloe* species in Europe during the last 30 years is apparant. From 14 species in Europe 7 species are known in Southern Germany. Only 5 species *Meloe brevicollis*, *M. proscarabaeus*, *M. rugosus*, *M. scabriusculus* and *M. violaceus* are recorded since 1970. Recent information is only existing on *M. violaceus*.

**S15.2.** CURRENT TRENDS IN SCREWORM (DIPTERA: CALLIPHORIDAE) MYIASIS  
**14** IN THE CARIBBEAN REGION

Dr. S.C. Rawlins

**ABSTRACT** In a random sample of animal producers and animal health personnel, 33% of the respondents in Trinidad, 15% in Guyana, 11% in Suriname and 3% in Jamaica recalled at least one case of human myiasis due to *Cochliomyia homivorax* (Coquerel). During 1981, respondents in Suriname (88%), Jamaica (90%), Guyana (85%) and Trinidad and Tobago (82%) found at least one case of myiasis in their livestock, mainly cattle, pigs and dogs. Feral animals, e.g. jaguars, were also found to be infested. The initial wounds were mainly the umbilicus of neonates, whereas arbitrary wounds, and vampire bites were also affected. Fifty-three to 78% of all respondents examined their livestock daily for wounds and infestation by the screwworm. Daily examinations of livestock are now done as a result of the screwworm threat. Annual estimates of losses (in U.S. dollars) due to surveillance and medication ranged from \$4.82 to \$10.71 per animal.

**S22.2.**  
**11**

THE HEMEROBIIDAE OF MONGOLIA

ALEXI POPOV

National Natural History Museum, Boul. Russki 1, Sofia, Bulgaria

The previous results of examination on Mongolian materials of Hemerobiidae (Neuroptera), collected from Soviet-Mongolian expeditions during the years 1967 - 1976, are reported. The collection comprises 322 specimens from 19 completely identified species. Two species are new for Asian and 8 are new for Mongolian fauna. The hitherto data treat 17 species. The dominants are arboreal species (4 Holarctic, 8 Siberian, 4 Central- and East-Asiatic) and 3 species are eremials only. The most widespread are *Wesmaelius kaszabi* and *Hemerobius poppii*.

## 522.2. 3

### Neuropterology in southern Africa

M W Mansell

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Twelve families of Neuroptera, comprising about 444 species in  
123 genera, occur in southern Africa. The varied climate,  
topography and vegetation of the subcontinent provides  
numerous habitats for this rich fauna. The following families,  
with approximate numbers of genera and species, are represented:  
Coniopterygidae (9, 30); Sisyridae (1, 4); Osmylidae (1, 3);  
Berothidae (5, 10); Dilaridae (1, 1); Psychopsidae (3, 6);  
Hemerobiidae (7, 22); Chrysopidae (17, 79); Mantispidae (4, 35);  
Ascalaphidae (21, 61); Nemopteridae (14, 59);  
Myrmeleontidae (40, 134).

## 522.2. 6

### Biology and phylogeny of the Crocinae (Neuroptera: Nemopteridae)

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The subfamily Crocinae (Neuroptera: Nemopteridae) has four  
main centres of distribution. Twenty one species occur in the  
southern Palaearctic Region, extending from Spain and Algeria  
in the west, across to Afghanistan in the east; ten species have  
been recorded from southern Africa, five from South America and  
six from Australia. Larvae inhabit caves, old deserted  
buildings, rock crevices and small recesses under stones. Some  
species have greatly elongated prothoraxes and all crocine larvae  
predators. The modified hindwings and flight patterns of the  
adults enable them to fly and mate in very confined spaces, an  
adaptation to life in small caves and hollows.



P1.-  
23

THE MALE GENITALIA OF BUMBLE BEES (HYMENOPTERA, APIDAE):  
STRUCTURE, FUNCTION AND EVOLUTION.

PAUL H. WILLIAMS

Department of Applied Biology, University of Cambridge,  
Pembroke Street, Cambridge, CB2 3DX, UK.

The male genitalia of bumble bees present many multi-state characters which have been used frequently in studies of bumble bee systematics following Radoszkowsky's paper in 1884. The cladistic method is used here for the first time to classify sixty species by characters selected for their functional importance. A system of three genera is recommended, preserving the holophyletic groups Mendacibombus Skorikov, Psithyrus Lepeletier and Bombus Latreille, with the retention of the named subgroups of Bombus in subgeneric status.











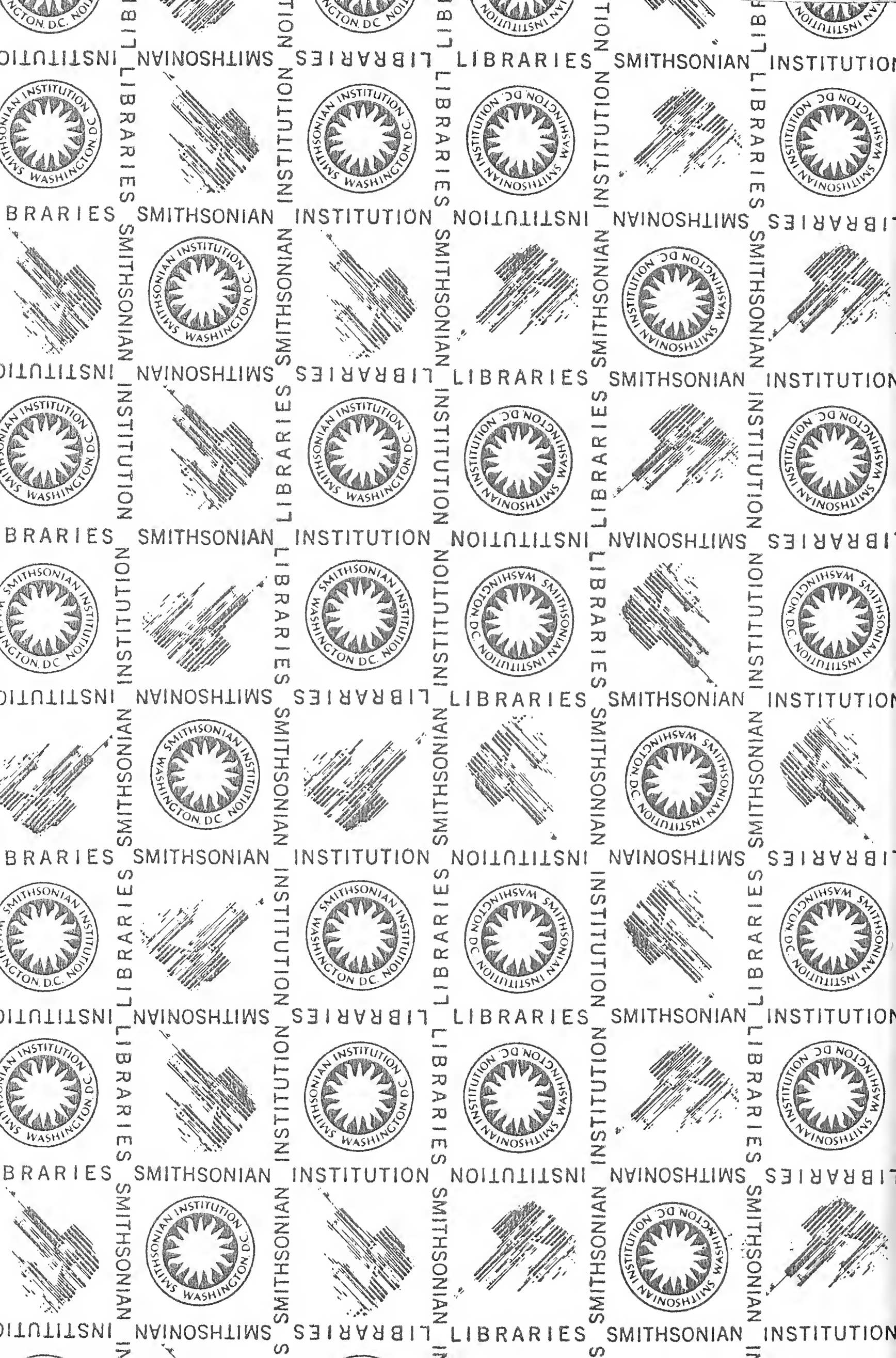


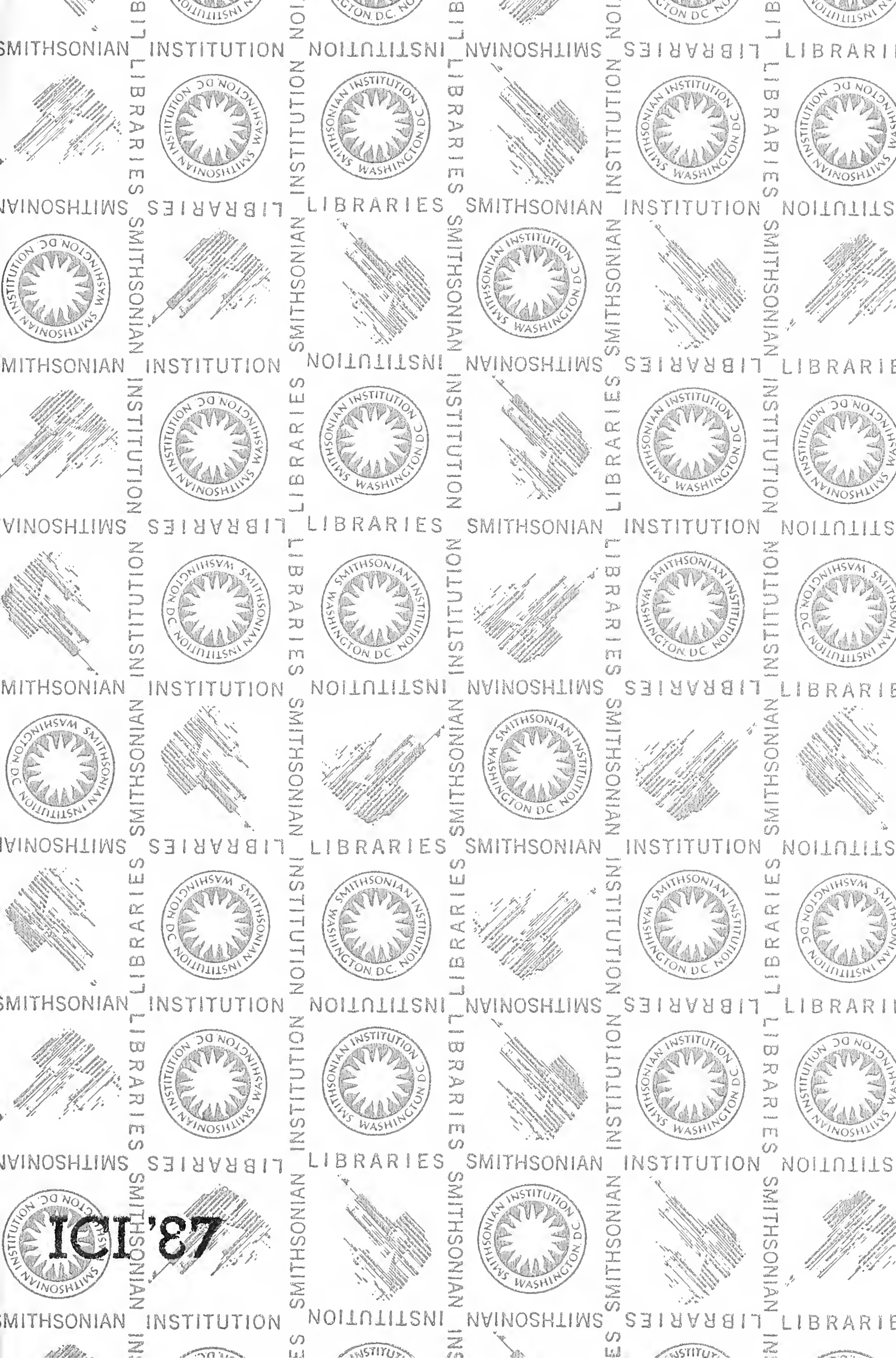












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Abstracts :